EERING
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ENGINEERING:

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EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

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ENGINEERING AND MARINE EXHIBITION AT OLYMPIA,

INCORPORATING THE FOUNDRY TRADES' AND WELDING EXHIBITIONS.

(*Continued from page* 200.)

ONE of the most interesting exhibits on the stand of the Wellman Smith Owen Engineering Corporation Limited, Victoria Station House, Victoria-street, London, S.W.1, is a working model of the Wellman patent level-luffing portal-type jib crane. This crane operates on principles which are stated to be entirely new, and is illustrated in Figs. 26 to 29, on this page. It is designed primarily for handling such bulk cargoes as coal and iron ore and is seen in Fig. 26 engaged on this operation at a French port, the particular example shown being the first British post-war crane to be supplied to the French Government for dockside re-equipment. A detail, to be referred to later, is seen to a larger scale in Fig. 27, but the principle employed is best understood from the diagrammatic views of Figs. 28 and 29, which are, however, simplified and not drawn to scale. In the types of level-luffing cranes hitherto available, the jib is hinged at the base and is merely altered to the inclination desired from this basal pivot, the maintenance of the load at the same level through a change of jib inclination being effected by an additional hinged member at the tip of the jib or by some other means. In the Wellman level-luffing crane the fixed-position pivot, or hinge, at the base of the jib has been discarded and the jib pivot has been given a movement such that the adjustment of the hoisting rope is made automatically within the limits of inclination, the level of the load remaining constant during luffing and slewing, without drum manipulation.

Examining Fig. 26 in conjunction with Figs. 28 and 29, it will be seen that the structure of the crane above the rotating base consists of a tapering steel frame, the lower part of which is occupied by the machinery house. At the apex of this structure is a pivot shaft *a* which forms the fulcrum of a pair of massive levers *b*; the free end of these levers carries pivots *c* at the base of the jib *d*. The jib is of more or less conventional construction as regards its body, but at its lower end is formed with a rigid diamond-shaped frame. Two of the members of this frame are indicated in Figs. 28 and 29 at *e* and *f*, respectively. The lower end of member *f* is connected by a pivot to the free end of the swinging arm *g*, which is anchored to the base at the pivot *h*. The triangular structure at the lower end of the jib and in line with the body carries a set of sheaves for the hoisting ropes. The crane is shown in Figs. 28 and 29, with the jib at the approximate inclination to give the minimum and the maximum outreach, respectively. It will be clear from a comparison of these two diagrams that the position of the jib pivot *c* is greatly different in the two extreme positions and that the inclinations of the lever *b* and the arm *g* are also different. It is from the restraint imposed by the lever and arm that the jib is inclined as desired.

Power must be supplied to the lever *b* when its inclination and that of the jib are to be altered. This power is provided by the screw *i* attached to the lever *b* as shown and having a motor-rotated nut *j* situated on a platform above the top of the machinery house. There are actually two screws and nuts, as will be clear from Fig. 27. The motor driving the nuts lies above the structure carrying them, but is hidden from view in Fig. 27; in the crane illustrated in Fig. 26 it is of 35 brake horse-power when running at 970 r.p.m. Referring again to Figs. 28 and 29, it will be clear that extension or retraction of the screws will change the

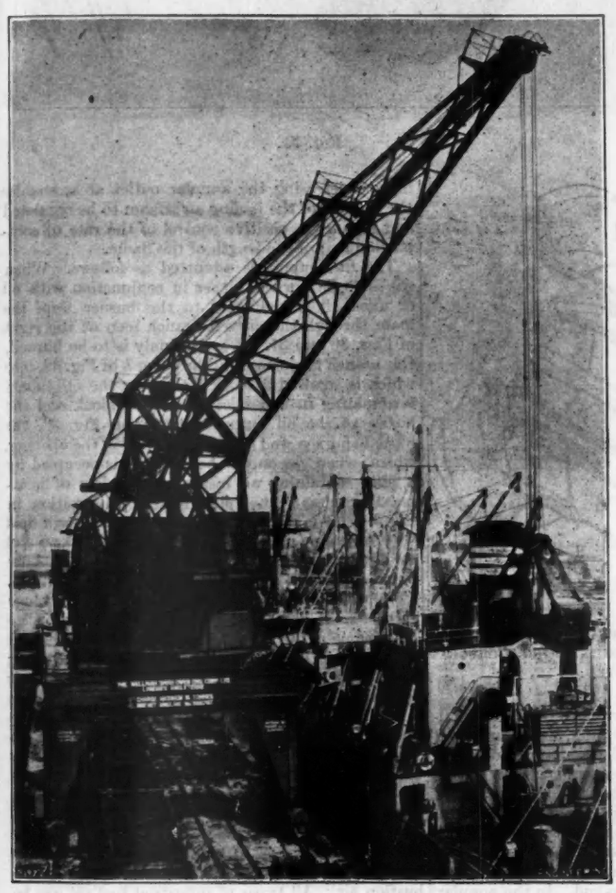


FIG. 26.

FIG. 27.

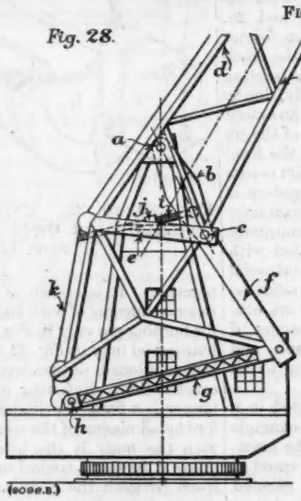


Fig. 28.

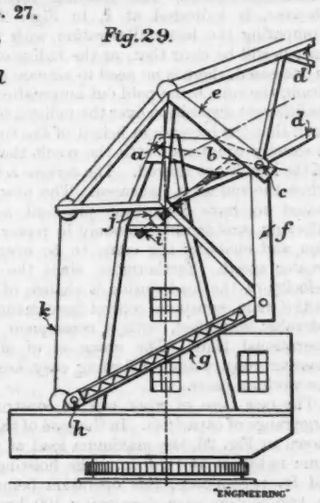


Fig. 29.

(scale B.) "ENGINEERING"

FIGS. 26 TO 29. 15-TON LEVEL-LUFFING PORTAL CRANE; THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED.

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.

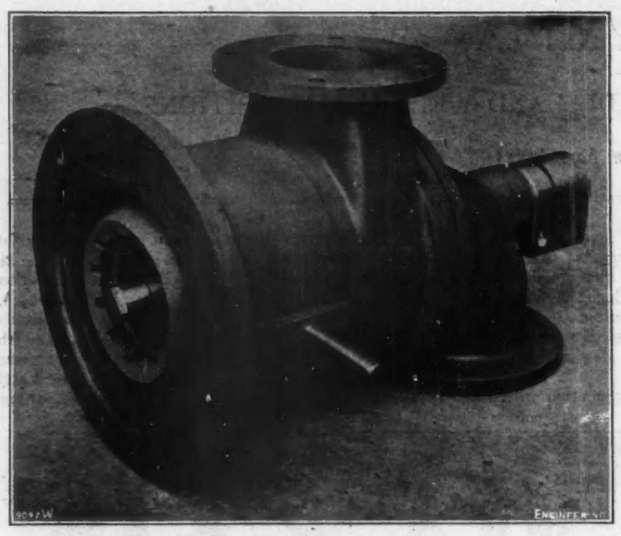


FIG. 30.

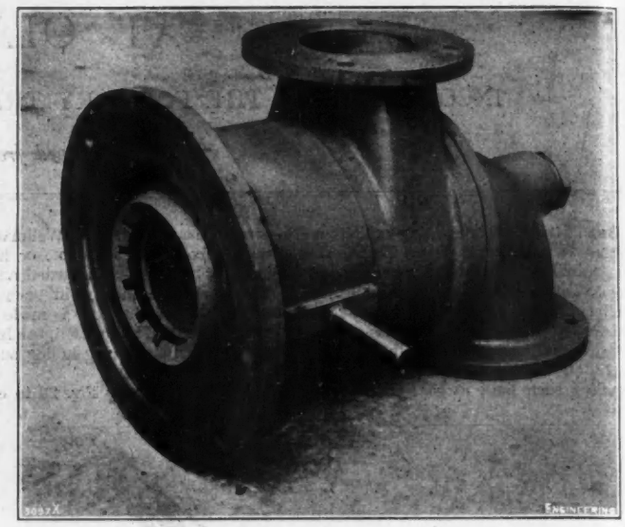


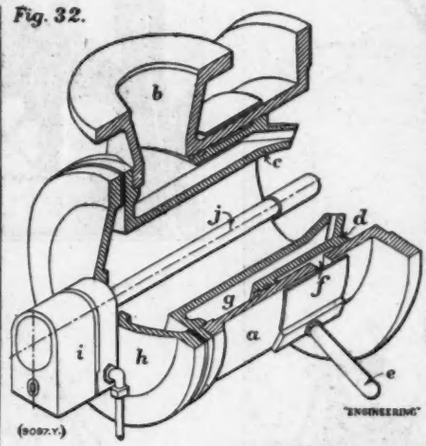
FIG. 31.

position of the jib pivots *c* and, through the member *f*, that of the arm *g* also. The geometry involved in these movements is of great interest, but cannot be followed in detail here. One point, however, may be mentioned, namely, that the proportions of the several elements are such that the jib is self-balancing, the mid-length of the jib being vertically over the point of intersection of the lever *b* and the arm *g* when these are produced at whatever inclination the jib may be required to assume. There is, in addition, a correcting factor for any variation of the centre of gravity of the jib with respect to the mid-length point. The hoisting rope, with its sheaves, is indicated at *k*, in Figs. 28 and 29. Comparing the latter illustration with the former one, it will be clear that, as the radius of the crane is decreased, there is no need to actuate the hoisting drum, the rope being paid out automatically, due to its different disposition over the pulleys, to an extent such that the increase in height of the tip of the jib is exactly countered, with the result that the level of the load is not altered. The reverse action occurs when the radius is increased. The new system is stated to have important practical advantages, effecting considerable economy in power consumption and enabling the crane to be operated with greater speed. Furthermore, since the horizontal velocity of the load during a change of radius is, in the main, constant, control movements are considerably simplified, with a consequent saving of operational time. The crane is of simple and massive construction, affording easy access to all the working parts.

The new type of crane can be constructed in a large range of capacities. In the case of the example shown in Fig. 26, the maximum load at the maximum radius is 34 ft. 6 in. The hoisting speed is 154 ft. per minute, this operation being effected by two motors each developing 100 brake horse-power at 735 r.p.m. For slewing, a motor of 24 brake horse-power at 730 r.p.m. gives a turning speed of 1 r.p.m. The luffing motors have already been referred to; the time taken to change from the maximum radius to the minimum one is 23 seconds. The total lift is 131 ft. The rail centres are 34 ft. 6 in. and a motor on each of the four bogies, developing 24 brake horse-power at 730 r.p.m., gives a travelling speed of 114 ft. per minute. The crane is shown fitted with a grab, but for handling ordinary cargo a change to a spreader beam and lifting hook can be readily made.

Another new exhibit on the stand of the Wellman Smith Owen Engineering Corporation is the universal burner illustrated in Figs. 30 to 32, above, which can be used, with only minor alterations, to burn either gas or oil separately or both fuels

Fig. 32.



FIGS. 30 TO 32. UNIVERSAL BURNER; THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, LIMITED.

together. It is shown as arranged for the simultaneous burning of both fuels in Fig. 30; as arranged for burning gas only in Fig. 31; and as arranged for burning oil only in Fig. 32, the sectional view in this last-mentioned illustration showing the details of construction. Referring to it, the body *a* of the burner is a flanged cylinder formed with a branch *b* for the admission of the combustion air. Concentric with the body is the internal flanged cylindrical sleeve *c*, having a conical open end. In the annular space between the body and the fixed sleeve is a sliding sleeve *d*, which also has a conical open end, but which is formed with notches as can be seen in Figs. 30 and 31. The sleeve *d* is traversed axially by means of the handles *e*, there being a handle at each side connected by a semi-cylindrical strap. The handles are screwed into the sleeve *d* and pass through a slot *f* cut in a helical path in the body of the burner. The slot extends round about one-sixth of the circumference on each side of the body and it will be seen that twisting the sleeve by means of the handles also traverses it axially in the body, a movement which decreases or increases the width of the annular opening between the conical ends of sleeves *c* and *d*. The packing ring at the plain end of sleeve *d* is only fitted to the larger burners of the series and prevents leakage of the combustion air occupying the annular space *g*. The axial traverse of the sliding sleeve, by decreasing or increasing the annular outlet area, enables the velocity of the issuing air stream to be regulated and thus gives positive control of the rate of combustion and of the length of the flame.

The fuel supply is admitted as follows. When gas is to be burned, either in conjunction with oil or alone, it is delivered to the burner from the main through the curved branch seen at the right of Figs. 30 and 31. When oil only is to be burned, this branch is replaced by the cover *h* of Fig. 32, into which is screwed a block *i* carrying the oil tube *j* terminating in a nozzle. Both the block and the nozzle of the oil burner are seen in Fig. 30, the block being screwed into the gas bend in the opening, which, when gas only is being fired, is occupied by a plug containing an inspection window of heat-resisting glass; this plug is seen in position in Fig. 31. It is stated that the new burner will deal with any type of industrial gas, whether clean and cold or hot and dirty. The combustion air pressure for gas only is 6 in. water gauge for a short flame. The maximum gas pressure is 0·4 in. water gauge for the short flame and 1·0 in. water gauge for the long flame; the long flame may be from 30 to 180 per cent. longer than the short flame, according to load. The CO_2 percentage attainable with either the short or long flame is claimed to be within 1 per cent. of the maximum theoretical value obtainable. The combustion air and gas can be preheated up to 300 deg. C. when the burner is of ordinary cast-iron construction; for temperatures higher than this, heat-resisting metal is employed.

When used for gas and oil simultaneously, the burner is arranged as in Fig. 31, no alteration being necessary to the supply and control of the combustion air. All types of industrial fuel oil can be burned, but the viscosity should be of the order of 100 seconds Redwood No. 1; it is necessary, therefore, to heat heavy fuel oil to 190 deg. F. and medium fuel oil to 130 deg. F. The oil is atomised by either steam or air at a pressure of 25 lb. per square inch. There are separate inlets for air and fuel, and the burner tube has an inner concentric tube so that the two streams are kept separate until the point of atomisation at the tip of the nozzle is reached. The rate of combustion is controlled by adjustment of the oil delivery pressure, and the quantity of the atomised steam or air by adjustment of its delivery pressure. The burner is normally used with the sliding sleeve set to give a short flame with gas alone, but it is possible to obtain a longer flame by adjustment of this slide. It is stated that CO_2 values between 12 per cent. and 15 per cent. are easily obtainable and the flame is clear and smokeless, without emission of particles of imper-

THE ENGINEERING AND MARINE EXHIBITION.

FIG. 33.

Fig. 34.

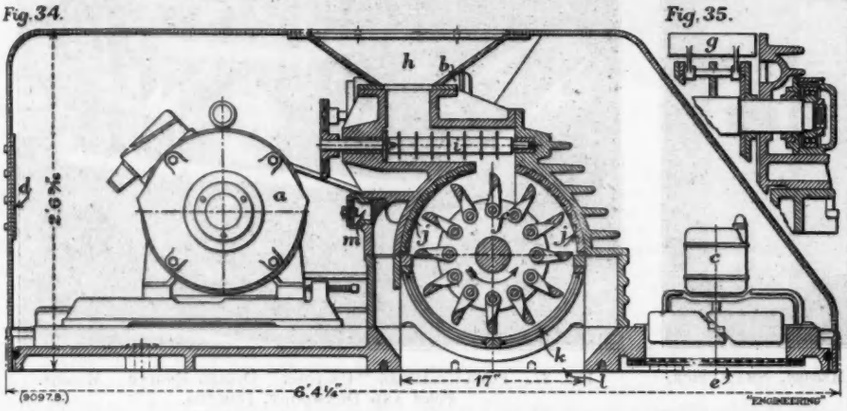


Fig. 35.

FIGS. 33 TO 35. "ATOMILL" PULVERISER; MESSRS. BRITISH JEFFREY-DIAMOND, LIMITED.

fectly burned oil. For oil burning only, the maximum oil pressure should not exceed 16 lb. per square inch; the atomising pressure, as already stated, should be 25 lb. per square inch and the combustion air pressure should be 6 in. water gauge. The consumption of atomising air ranges from 0·33 lb. to 0·5 lb. per pound of oil, according to the size of the burner; when steam is used for atomising, the range is from 0·25 lb. to 0·45 lb. per pound of oil.

The machine for the fine pulverisation of a variety of materials, shown in Figs. 33 to 35, above, is known as the "B.J.-D Atomill," and is made by Messrs. British Jeffrey-Diamond, Limited, Stennard Works, Wakefield. The machine will reduce, at one operation, materials averaging ¼ in. cube to powders such that from 75 per cent. to 99 per cent. will pass through screens of up to 300 mesh. The production of powders of this degree of fineness is usually attended, unless precautions are taken, with the escape of a portion in the form of dust, which may be wasteful, unpleasant, or deleterious, according to the material being treated. It is claimed that the Atomill is wholly dustless in operation, a characteristic which, no doubt, owes something to the highly-finished cover, part of which is seen in Fig. 33, though its primary purpose is to provide a guard for the motor drives. These drives consist of a 15-h.p. continuously-rated screen-protected squirrel-cage motor for the mill rotor, a ½-h.p. motor of the same type for driving the feed screw, and a second small motor for driving an exhausting fan. The main motor drives the rotor through eight V-belts, the rotor speed being 5,000 r.p.m. The motor is indicated at *a* in Fig. 34, while the feed-screw motor is indicated at *b* and is visible also in Fig. 33. The fan motor, seen at *c* in Fig. 34, is not invariably required, but when it is fitted, it induces a stream of air through the cover grilles at *d*. The air flows over the motors and the cooling fins of the mill and is discharged through the opening *e* into a suitable duct in the machine foundation.

The rotor of the mill, indicated at *f* in Fig. 34, consists of three discs carrying 12 hinged hammers *g* (Fig. 35). These are curved to a special contour at the back and have a flat working face, the direction of rotation being counter-clockwise as seen in Fig. 34. The material to be reduced is fed into the hopper *h* and gravitates to the feed screw *i*, which delivers it above the hammers. So long as the feed screw is covered with material no dust from the interior of the mill can escape upwards. The feed-screw drive is through chain reduction gear and the screw itself is readily detachable from the driven shaft; the rate of feed depends upon its pitch, the revolutions per minute of the screw being modified to suit the particular material handled. The material falling on the hammers, the peripheral speed of which is about 18,850 ft. per minute, is reduced by impact with the hammers and by being thrown against the serrated grinding plates *j*. The reduced material falls on to the screens *k*, through which the particles that are small enough pass for collection in a suitable receptacle through the opening *l*. The oversize material is carried round for further reduction, there being, of course, a strong fan action from the rapidly-rotating hammers. The connection seen at *m* in Fig. 34 is to admit air or gas to the interior of the mill when required. When dealing with material having a low melting point, cold air is admitted, but when explosive materials are to be handled the connection is modified to admit inert gases supplied from outside the Atomill. The body of the mill is usually of cast iron, the serrated grinding plates are of a wear-resisting alloy and the hammers are tipped with a similar material.

The rotor shaft is carried in double-row self-aligning ball bearings, shown in Fig. 35, which are housed in plummer blocks separate from the body of the mill. There is a labyrinth seal on the side next to the body. The bearings are lubricated from outside the casing by grease gun. The rotor is dynamically balanced, and the hammers are also balanced in sets so that renewal is accurately performed when necessary. The inside of the machine, as will be evident from Fig. 33, is readily accessible for the cleaning necessary, for example when grinding pigments, the colour of which may be different in different batches. The Atomill cannot be choked, as the feed screw is electrically interlocked with the rotor driving motor so that it can only operate while the mill is running. The capacity of the Atomill varies with the material to be reduced. As examples it may be noted that with barytes, which is of a fairly friable nature, 4,500 lb. of material can be handled per hour with 99 per cent. passing a 200-mesh screen. With gypsum, the output is 3,000 lb. per hour, 90 per cent. of which passes a 100-mesh screen. Pigments can be reduced so that 98 per cent. passes through a 200-mesh screen at the rate of 800 lb. per hour. Titanium oxide is handled at the rate of 2,000 lb. per hour, 99·9 per cent. passing through a 325-mesh screen. The machine will handle such differing materials as food products, fertilisers, etc. Other exhibits on this stand are the British Jeffrey-Diamond swing-hammer pulveriser for reducing friable material to products between ¼ in. cube and 100 mesh; of this machine there is a range of 11 sizes. There is also shown the firm's V-4 air engine. This is a compact machine driven by compressed air. There are four cylinders, arranged in two pairs inclined at 90 deg. with a single rotary valve in the angle. There are three standard sizes with outputs of 15, 20 and 25 brake horse-power, respectively, when the supply air pressure is 60 lb. per square inch.

Among the relatively few machine tools to be seen in the exhibition is the 3½-in. centre lathe shown by Messrs. Smallpeice, Limited, Parkshot, Richmond, Surrey, and illustrated in Fig. 36 on page 220. This lathe is designed on precision lines for use in research laboratories and by instrument manufacturers, gauge makers, tool makers, etc. The height of centres is 3½ in. and the length admitted between them is 19 in. The maximum diameter of work over the saddle is 4½ in., but the centre way has a gap in front of the headstock which admits faceplate work up to 8 in. in diameter by 2¾ in. thick. The top slide swivelling on the saddle, has a traverse longitudinally of 3½ in., the traverse of the cross slide below it being 3¾ in. The drive is by a variable-speed motor which gives a stepless range to the spindle speeds. Transmission is by a flat belt, the driven pulley being carried on ball bearings so that the belt pull is taken off the spindle. Connection between the pulley and spindle is either direct, through a floating clutch sleeve, or through back-gears. With direct drive the range of spindle speeds is from 20 r.p.m. to 2,000 r.p.m., but if the back gear is engaged these speeds can be lowered or increased. Fig. 1 shows on the front of the base the stop and start buttons and a three-position switch giving forward, reverse and "off" control. In the last-mentioned position a dynamic brake is applied which brings the spindle rapidly to rest, though it does not prevent the spindle from being turned by hand when required. The speed variation is obtained by turning the knob seen at the left of the cabinet, the speed in use being indicated in r.p.m. on the dial seen on a pillar at the centre of the bed. This pillar also carries a tool tray, a drawing holder and an adjustable lamp.

The spindle is carried in plain bearings in adjustable conical seatings. It has a central hole through it to clear work ¾ in. in diameter, but a centre and draw-tube is provided, as seen in the illustration. The spindle nose has a combined taper and face location, ensuring correct concentricity. The headstock centre, or collet, whichever is in use, engages directly in the taper and the parallel spindle bore;

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.

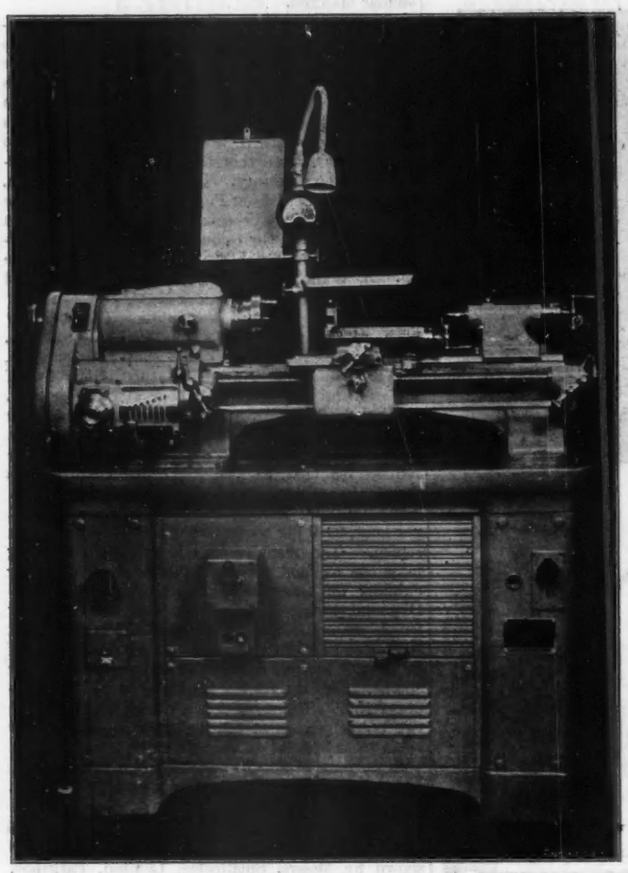


FIG. 36. 3½-IN. CENTRES PRECISION LATHE; MESSRS. SMALLPEICE, LIMITED.

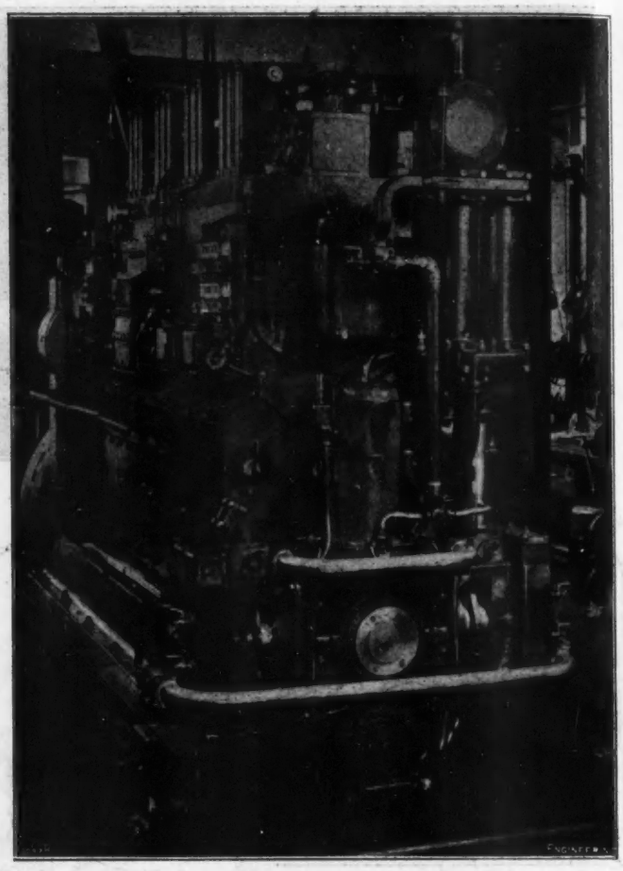


FIG. 37. FOUR-CYLINDER "UNIPORN" DIESEL ENGINE; MESSRS. PORN AND DUNWOODY, LIMITED.

the standard collets admit work up to ½ in. in diameter. Below the headstock can be seen the "magazine" gearbox for the screwcutting feeds. The gearbox departs from the conventional type in several particulars; there are no open slots through which swarf can enter on the front of the box, the tumbler gear is large and slides on a multi-splined shaft, and it runs in an oil bath. The large dial seen to the left of the tumbler lever, in conjunction with the magazine gearbox, enables the selection of four other gears to be made and thus permits standard threads to be cut without recourse to change gears. For special, metric and British Association threads, change gears are employed. Forward and reverse directions of the turning, surfacing and screwcutting traverses are controlled by a knob operating the tumbler gears. The saddle is simple in construction, and two solid lead-screw nuts, widely spaced to distribute wear, are employed. They are adjustable longitudinally towards or away from one another, to eliminate backlash. A crank-handle at each end of the lead screw enables the operator, when employing hand traverse of the saddle, to use either hand at will. The saddle traverse is measured by means of a large dial with a vernier scale reading to 0·0001 in., while similar vernier scales are fitted to the top slide, the cross slide and the tailstock. The top slide has also a scale, for swivelling, reading to five minutes of arc. The saddle slides on a pair of inverted V-ways. Between these is a combined flat and V-way on which the tailstock slides; it is this central way that is interrupted to form the gap for large faceplate work, alluded to above. The ways are hardened, ground and lapped. The tailstock is provided with cross adjustment for taper turning. The centre is actuated by a crank handle and the tailstock is secured to the bed by an eccentric clamp and levers. The machine is distinguished by the makers as the Cromwell type S.800 3½-in. precision lathe.

The name of the "Uniporn" Diesel engine, illustrated in Fig. 37, above, is derived from the title of the manufacturers, Messrs. Porn and Dunwoody, Limited, Union Works, Bear-gardens, London, S.E.1. The type was, until recently, known as the "Union" engine. The design is based on that of the German Deutz Diesel engines, of which, before the recent war, Messrs. Porn and Dunwoody were the sole concessionaires in Great Britain. Since the war, however, importation has stopped and the firm now build the engine under the above name. It is claimed that this new British product is an improvement on the original German engine, but in view of the extent to which the Deutz engine is in use, the "Uniporn" engine has its parts interchangeable with those of the corresponding original engine, so that, if spare parts are required, both the British and German engines can be catered for. The Uniporn marine engine, Type U.D.V. 50/66, is of the four-stroke cycle single-acting type, and is made in five sizes, from three cylinders to eight cylinders, the particular engine illustrated having four cylinders. The cylinder diameter is 11·02 in. (280 mm.) and the stroke is 17·72 in. (450 mm.). The long stroke enables the requisite power to be developed at a comparatively low piston speed, the output per cylinder at 300 r.p.m. being 50 brake horse-power, with a mean effective pressure of 80 lb. per square inch, a compression pressure of 441 lb. per square inch and an average ignition pressure of 706 lb. per square inch. The fuel consumption is stated to be from 0·36 lb. to 0·375 lb. per b.h.p. per hour, and the exhaust temperature, at 330 r.p.m., about 360 deg. C.

The four cylinders are a monobloc casting, the outer walls of which are continued down to the level of the centre of the crankcase, which is itself a single casting. The two castings are connected by through tie rods. The cylinder head, containing the valves, is a third single casting. The cylinders have interchangeable liners, surrounded by wide water-spaces, and the cylinder head is also water-cooled. The auxiliaries, seen in the foreground, consist of a two-stage air compressor in the centre with a circulating water pump and a bilge pump at the sides lower down. The prominent cross-connecting pipes between the suction and discharge boxes enable either pump to be used for either duty; the change can be effected while the engine is running. All three auxiliaries are driven by a single eccentric on the crankshaft. The air-compressor cylinders are water-cooled and charge the starting bottles to a pressure of 450 lb. per square inch. Above the compressor is a duplex-gauze oil filter through which the lubricating oil is passed by a reversible gear-type pump. On leaving the filter the oil passes through the adjacent cooler and is then delivered to the main bearings, big ends and gudgeon pins at a pressure of 30 lb. per square inch. The oil from the crankpit is pumped up to a tank on the side of the engine, whence it flows by gravity to the suction of the forced-lubrication pump. The cylinders are lubricated by the mechanically-operated sight-feed lubricators seen at the left, in line with the oil filter. Beyond this group of lubricators is seen the fuel-pump block, which is made from a solid nickel-steel forging and tested by Lloyds to 7,350 lb. per square inch; standard fuel-injection equipment is used. Farther aft is the governor with its controlling handwheel. The engine speed is adjustable from 90 r.p.m. to its maximum. Beyond the governor the starting gear lever is visible. The three-cylinder and four-cylinder engines need separate reversing gear or a

THE ENGINEERING AND MARINE EXHIBITION.

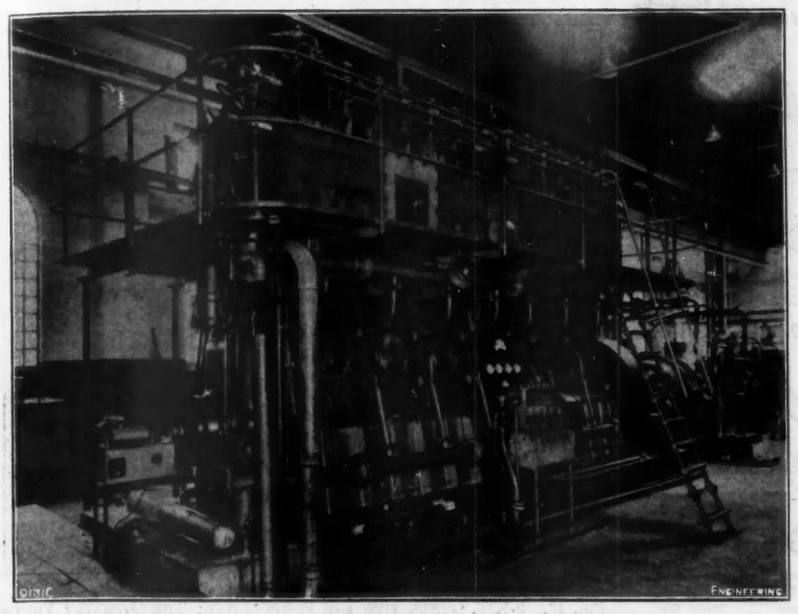


FIG. 38. SIX-CYLINDER 1,610-B.H.P. MARINE DIESEL ENGINE; MESSRS. RUSTON AND HORNSBY, LIMITED.

reverse-reduction gear, but the six-cylinder, seven-cylinder and eight-cylinder engines are directly reversible. Messrs. Porn and Dunwoody also show their H.10 horizontal single-cylinder four-stroke Diesel engine, which, with a bore of 4¼ in. and a stroke of 6½ in., develops 10 brake horse-power at 1,000 r.p.m. It is stated to be suitable for a variety of duties, such as driving concrete mixers, centrifugal pumps, winches, small locomotives, generators, compressors, etc.

An exhibit displayed for the first time is the 1,610 brake horse-power Diesel marine engine, mark 6 VOX.M, manufactured by Messrs. Ruston and Hornsby, Limited, London. It is illustrated in Fig. 18, above, set up for test in one of the firm's shops, so that some extraneous pipes and test mechanisms are visible The engine is of the four-cycle compression-ignition direct-injection type, incorporating an exhaust-turbo pressure charger. The particular engine illustrated has six cylinders, but the class ranges from five to nine cylinders, each cylinder having a rated output of 268 b.h.p. at 435 r.p.m. The cylinders are 17 in. bore by 18 in. stroke, and the fuel consumption at full load is 0·37 lb. per brake horse-power per hour. A deep bedplate carrying separate cast-iron columns supports the cylinder block, the space between the columns being filled in with removable panels having inspection covers. The cylinder block is water jacketed, the cylinder liners being of the wet type; this casting also forms a support for the camshaft, the fuel-pump operating gear and the pressure charger. This latter consists of a single-stage centrifugal blower driven by a turbine through which the exhaust gases are discharged. The blower impeller is of high-tensile steel throughout and is accurately balanced. The turbine rotor has a central disc to which blades of heat-resisting steel are welded. The turbine cylinder and inlet casing are amply water-jacketed. The shafts are fitted with labyrinth glands, having a compressed-air seal.

The cylinder heads have overhead inlet and exhaust valve gear, the valves being carried in cages, withdrawable without removing the cylinder heads. They also accommodate the fuel injector and the air-starting and relief valves. The injectors are of the spring-loaded multi-hole type and are fitted with a self-centring nozzle, a full inlet with an edge-type filter and a leak-off connection. There is a separate vertical fuel pump for each injector. The stroke of the plunger is constant and the quantity of fuel injected is varied by the governor control on a by-pass system. The engine camshaft is driven by chain from the crankshaft; and at the camshaft end is a gear drive to a second camshaft, operating the air-starter valves, so that the correct timing for starting is given to each valve, the valve-operating mechanism being held clear of the cams except when required for starting. Forced-feed lubrication is provided for all the main working parts of the engine except the valve gear, which has wick-feed lubricators. The pistons are cooled by lubricating oil which is supplied from the main pipe rail to them and returned, through swinging links, to the return pipe rail and thence to the lubricating oil tank. Although the engine exhibited is intended for marine propulsion and is uni-directional, requiring to be fitted with oil-operated reverse-reduction gear, the VOX type is made for industrial service and for driving generators for Diesel-electric propulsion. A simple reverse gear can be fitted to all but the five-cylinder size. There are also on Messrs. Ruston and Hornsby's stand two different types of marine propulsion engine of 60/90 brake horse-power and 200 brake horse-power, respectively, two engines coupled to generators of 30 kW and 100 kW, respectively, and a 15-brake horse-power engine coupled to a 5-kW dynamo and an air compressor.

Probably the displays of internal-combustion engines form the largest single class in the exhibition, and there is a wide choice among long-established manufacturers and those less-known hitherto. The Associated Equipment Company, Limited, Southall, Middlesex, for example, had just entered the marine-propulsion field when the outbreak of war suspended production of this type of engine. It has now been resumed and the company are showing an interesting pair, port and starboard, of six-cylinder marine Diesel engines developing 100 brake horse-power at 1,500 r.p.m., continuous rating. The cylinders are 120 mm. bore by 142 mm. stroke, and the engines are fitted with reverse gear and a 3 to 1 reduction gear, giving a maximum propeller speed of 500 r.p.m. The design incorporates dry-sump lubrication, fresh-water cooling and variable-speed governing. The company also show a stationary Diesel-driven generating-set design, based on large numbers of this type produced during the war. The engine is of the same output as the marine set and drives a 62·5-kVA 415-volt three-phase alternator through an A.E.C.-Spicer flexible coupling. The alternator, made by the British Thomson-Houston Company, is screen-protected, and has two bearings with an overhung exciter. This engine is radiator-cooled, the radiator being mounted forward of it, on a common fabricated-steel bedplate which also carries the complete 24-volt starting equipment.

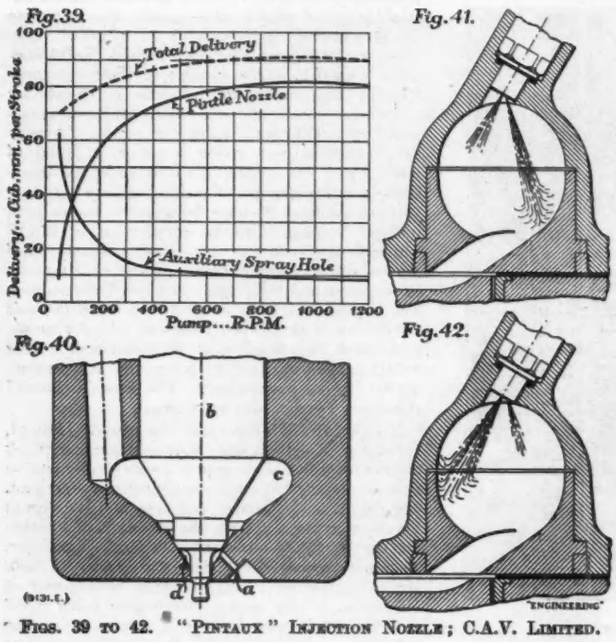
Messrs. Pelapone Engines, Limited, Lofthouse-gate, Wakefield, show a range of their Pelapone-Ricardo Diesel engines which includes a two-cylinder marine propulsion unit developing 20 brake horse-power at 1,000 r.p.m., hand-starting, with reverse and reduction gear giving a propeller speed of 500 r.p.m. The engine has self-contained circulating and bilge pumps. For ship auxiliary purposes, there is a similar 20-brake horse-power engine with radiator cooling, directly coupled to a 12-kW 110-volt direct-current drip-proof generator, and also a single-cylinder Diesel engine of 10 brake horse-power at 1,000 r.p.m., with sea-water cooling. This engine is directly coupled to a 6-kW 110-volt direct-current drip-proof generator, and, by means of a clutch, to a single-stage air compressor having a displacement of 15 cub. ft. per minute at a pressure of 350 lb. per square inch. The firm's industrial stationary range is also represented.

Messrs. H. Widdop and Company, Limited, Greengate, Keighley, show four cold-starting Diesel engines, of which the largest is a six-cylinder marine unit developing 180 brake horse-power at 400 r.p.m. The engine is of the two-cycle type and is designed for direct reversal; both the direction of rotation and the running speed are controlled by a single lever. It has independent cylinders and heads. A two-stroke engine developing 42 brake horse-power at 500 r.p.m. is also shown, this engine being fitted with the firm's epicyclic type of reverse gear. The other two engines are of the four-stroke cycle, one having three cylinders, being rated at 36/45 brake horse-power at 800/1,000 r.p.m. This engine has wet liners and is in use in refuelling launches for long-distance flying boats. The remaining engine is a single-cylinder four-cycle unit, of 5/7 brake horse-power, for auxiliary purposes.

Many of the exhibits of Messrs. C.A.V. Limited, Warple-way, Acton, London, W.3, have been previously shown at the recent British Industries Fair at Birmingham, and were described in ENGINEERING on May 23, 1947, page 426. An illustrated description of the manufacture of C.A.V. fuel-jet equipment is to be found in the present volume, on page 9, *ante*. There is, however, an interesting device shown for the first time, for which Ricardo patents are pending in all countries, this being the "Pintaux" injection nozzle, illustrated in Figs. 39 to 42, opposite. As is generally known, the widely-adopted Ricardo "Comet" type of cylinder head embodies a spherical combustion chamber in which, during the compression stroke of the piston, a violent rotating swirl is set up by the compressed air entering the chamber through a tangential passage between the cylinder and the chamber. The fuel, on being sprayed into this swirling air, is completely mixed with it and satisfactory combustion is ensured, but starting the engine when cold is not altogether easy unless a heater plug is employed to raise the temperature of the compressed air sufficiently to ignite the fuel. The Pintaux nozzle has been developed primarily to enable the heater plug to be discarded, and is the result of careful investigations in the precise distribution of the heat in the spherical chamber under starting conditions. Briefly, the new nozzle has, in addition to the ordinary pintle hole, an auxiliary injection hole through which the spray is first directed, though it is passed mainly through the pintle hole when the engine is running normally. There are thus two sprays entering the chamber, their relative volumes being as shown in the graph, Fig. 39.

Referring to the lower curve showing the discharge from the auxiliary hole, it will be seen that, when the fuel pump is running at, say, 50 r.p.m. the delivery per stroke is some 60 cub. mm., while that through the pintle nozzle is virtually negligible; indeed, at first, there is none. At 100 r.p.m. the intersection of the lower and upper curves shows the two sprays to be equal in volume; beyond that point the discharge through the pintle nozzle increases while that through the auxiliary hole decreases. The Pintaux nozzle is shown diagram-

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.



FIGS. 39 TO 42. "PINTAUX" INJECTION NOZZLE; C.A.V. LIMITED.

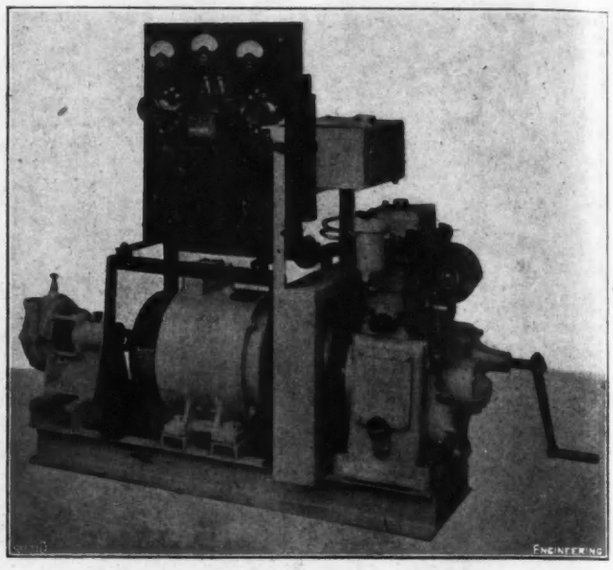


FIG. 43. 3-KW. GENERATING AND PUMPING SET; THE COVENTRY VICTOR MOTOR COMPANY, LIMITED.

matically in Fig. 40, the auxiliary hole being indicated at *a*. The relations of the two sprays are seen in Figs. 41 and 42. Starting conditions are shown in Fig. 41, the large jet representing the bulk of the spray; the direction in which the spray is discharged is towards that zone of the combustion chamber which investigation has shown to give optimum starting conditions. This direction, however, does not give optimum running conditions, so the spray is changed over, as the engine gets into normal work, to the position shown by the larger jet in Fig. 42. Two points to be noted in connection with this illustration, first, that the direction of the larger spray is precisely that taken with the usual arrangement of pintle, which experience has shown to give the best all-round engine performance; and, in the second place, that, although the bulk of the fuel is discharged from the pintle hole, there is a small spray from the auxiliary hole. This acts as a pilot charge and reduces combustion noise. The change of spraying conditions is wholly automatic apart, of course, from the normal crankshaft starting torque. Referring to Fig. 40, the pintle needle, shown at *b*, has a large conical end in a chamber *c* and below it is a smaller cone, seated in the pintle end, forming a small annular chamber *d* from which the auxiliary hole *a* is led. The oil pressure in chamber *c* builds up at starting speeds and becomes great enough to lift the needle slightly, at which point the oil is discharged through the auxiliary hole. At first, since the extreme end of the needle is parallel, this initial lift does not permit any discharge from the pintle hole, but at running speeds, when the fuel pressure is higher, the lift is sufficient to withdraw completely the parallel needle end from the pintle and the bulk of the fuel is discharged through the hole thus left; a small portion is discharged at the same time through the hole *a* as already explained.

Of the smaller internal-combustion engines there is an interesting display on the stand of the Coventry Victor Motor Company, Limited, Cox-street, Coventry, both compression-ignition types and petrol types being shown. An application of one of the former types is illustrated in Fig. 43, above, but, in addition, there are a number of units arranged for other duties, apart from examples of the engine alone. This engine, the Coventry "Victor" Diesel engine, is made in two models, both of the four-stroke single-cylinder water-cooled type. One of the models, with a cylinder 80 mm. bore by 100 mm. stroke, develops 5/7 h.p., while the other, having a cylinder 85 mm. bore by 100 mm. stroke, develops 7/9 h.p. The speed is controlled by a governor, stated to be accurate to within 3 per cent. between no load and full load, with a limited degree of adjustment. The engine can be fitted, if desired, with a governor with the wide range of control of between 800 r.p.m. and 2,000 r.p.m. The crankcase is of non-corrosive aluminium alloy. The crankshaft is of solid steel with an integral balance-weight. Pressure lubrication is effected by a gear-type pump driven from the crankshaft and delivering through a filter. The camshaft, hardened and ground, is driven by a duplex chain from the crankshaft. The valves are of the overhead type and have double springs. The valve gear is self-lubricated and is protected by easily removable covers. The fuel pump serves a pintle-type single-hole injection nozzle.

The unit shown in Fig. 43 consists of a "Victor" engine directly-coupled through the flywheel by means of a flexible coupling to a 3-kW generator An extension to the generator spindle drives a small centrifugal pump through a hand-operated dog clutch. The three elements of the set are compactly grouped on a fabricated-steel bedplate with a frame carrying a control switchboard, behind which is seen the fuel tank. No water supply is indicated in the illustration; this may be derived from a static tank, or, should the water being pumped be clean, a by-pass to the engine jacket can be taken from it, with a header tank to ensure a flow until the pump commences to function. Alternatively, the engine may be cooled by a radiator. Other units exhibited include a tank-cooled portable set with a flat-belt power take-off fitted to the flywheel, a two-gallon fuel tank and a tool locker. Being mounted on a fabricated steel bedplate and weighing only 4 cwt., the unit can be transported with relative ease. There is also an example of a portable pumping set which is capable of delivering 250 gallons of water per minute at zero head, 60 gallons per minute with 80-ft. head, or 50 gallons per minute with 100-ft. head at 1,500 r.p.m., continuous-duty running. Another engine shown can be fitted with a 2 to 1 or a 3 to 1 reduction gear, and there is one, for marine use, having a reduction (2 to 1) and reverse gear with a built-in circulating pump. The petrol-engine display includes the "Midget" horizontally-opposed twin-cylinder type, which can be used for such purposes as driving small air compressors, pumping plants, and generating electricity up to 1·5 kW, also for light craft propulsion and marine auxiliary work. The engine weighs approximately 50 lb. and measures overall 20¾ in. long by 18¾ in. wide by 15 in. high. A larger four-stroke horizontally-opposed marine engine, the "Neptune," developing 8/10 h.p., with reduction and reverse gear, is also shown, while the latest "Super 6" outboard unit, embodying a four-stroke midget engine, is of interest.

The exhibit of Messrs. Gleniffer Engines, Limited, Anniesland, Glasgow, W.3, consists of a pair of eight-cylinder marine Diesel engines, of which the starboard unit is shown in Figs. 44 and 45, above. This size and type of engine is to be fitted to a 75-ft. fishing boat of unusual interest, now building. The engine is a modification of a design used during the war in 72-ft. naval launches. It is known as "Model D.C.8," and the examples exhibited will each develop 160 h.p. at 900 r.p.m., driving propellers through reduction gears having a ratio of 2 to 1. The main features of the original design are, in general, little altered. The chief features are the horizontal valves, which arrangement accounts for the low headroom required and gives its distinctive appearance to the engine. The view of Fig. 44 is from the inlet-valve side, a continuous casing housing the valve gear; the exhaust valves are on the other side of the engine. The exhaust gear for each cylinder is contained in a separate box, through which the camshaft runs, this shaft being in sections for easy removal. Above these boxes is seen the water-jacketed exhaust manifold, and at the forward end is the cover for the camshaft drive, which consists of a duplex roller chain. The camshaft is immersed in oil and the push rods for the inlet valve are carried horizontally between the cylinder heads. The inlet valve is in a cage, the removal of which allows the exhaust valve to be drawn out through the opening thus left. The sprayer is situated vertically on top of the heads and discharges into the combustion chamber between the opposed valves. It is of the pintle type with a single hole.

The fuel pumps are seen in two groups of four each, in Fig. 44. They are actuated by a camshaft through tappets with rollers and have a constant stroke, regulation of the fuel delivery being effected by rotating the plunger on its axis; a helical recess cut on the plunger varies the duration of injection according to its position relative to a port in the pump cylinder. The projecting sockets on the pump assemblies are for the insertion of a portable

THE ENGINEERING AND MARINE EXHIBITION.

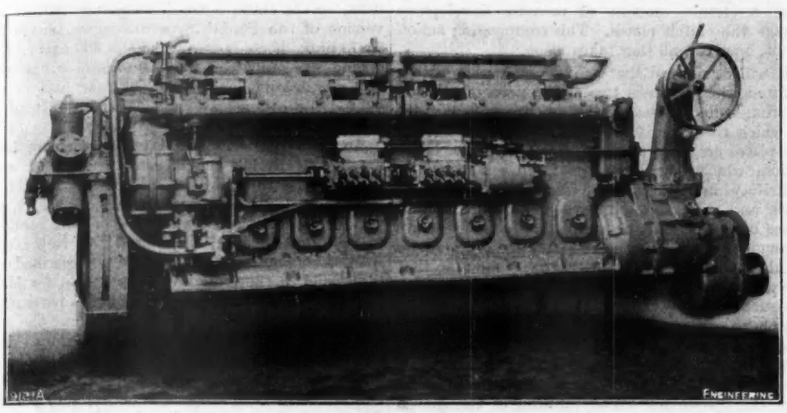


FIG. 44.

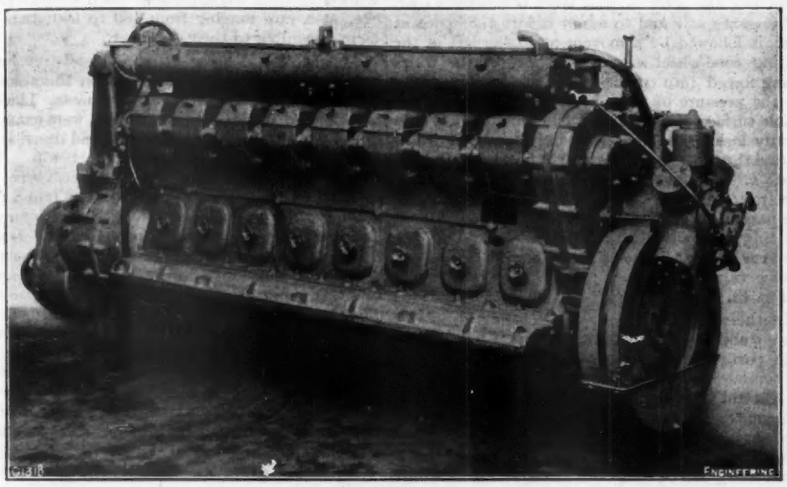


FIG. 45.

FIGS. 44 AND 45. EIGHT-CYLINDER 160-H.P. MARINE DIESEL ENGINE; MESSRS. GLENIFFER ENGINES, LIMITED.

handle by means of which each sprayer can be primed or cut out of action. The totally-enclosed centrifugal governor is seen at the right of the pumps; a single lever enables the speed of the engine to be adjusted to the desired rate. A characteristic feature of the engine, best seen to the right of Fig. 45, is a four-cylinder starting air motor, the shaft of which carries a pinion meshing during starting with a toothed ring on the flywheel. In starting, the inlet valves are opened to relieve the cylinder compression, unless the receiver pressure is fairly high; air is then admitted from the receiver to the air-motor cylinders, this operation is followed by the engagement of the pinion and consequent rotation of the crankshaft. The inlet valves are then closed and the pinion is automatically disengaged, the sequence of events being effected by the operation of a single lever or wheel. A receiver-charging valve is fitted to one cylinder head; the fuel pump for this cylinder is cut out and the valve opened, when, on the engine being run, the cylinder functions as an air pump to restore the receiver to its normal pressure. On this pressure being reached, the valve is closed and the cylinder again takes up normal firing. By this means the receiver can be recharged without any extraneous help. There are, however, certain losses, so that the process cannot be continued indefinitely, though experience has shown that an air receiver having a capacity of 3 cub. ft. at a pressure of 350 lb. does not need recharging by the auxiliary compressor until it has started a four-cylinder 80-h.p. engine more than 30 times.

The cooling-water system, which is served by double-acting plunger-type pumps, has thermostatic control and has been remodelled since the original design was made. The control pedestal, seen to the right of Fig. 44 above the reverse gear, is also new. The reverse gear has metal-to-metal cone clutches which operate with sliding keys in helical keyways. For ahead motion, no gears are in action. Reverse gears of the bevel type give the same speed for astern motion. A little over one revolution of the handwheel causes reversal.

A change of address of a well-known firm manufacturing the smaller types of Diesel oil engines may be noted here, in connection with Messrs. Ailsa Craig, Limited, formerly at Strand-on-the-Green, London, W.4, but now established in Ashford, Kent. The firm's exhibit consists of representative examples of some of their standard products. On the marine-propulsion side are the single-cylinder 10-h.p. engine, with combined clutch and reverse gear, the two-cylinder 20-h.p. engine, the four-cylinder 40-h.p. engine, and the six-cylinder 60-h.p. engine, the largest engine having separate clutch and reverse gear, and the 20-h.p. and 40-h.p. sizes having the clutch, reverse, and reduction gear in one unit. The industrial side is represented by a 60-h.p. six-cylinder engine and an 18-kW Diesel-electric generating set. The chief difference between the marine and industrial sets is that the latter are mounted on bedplates suitable for land installation, with pulley drives, or are arranged as semi-portable units, etc.

The exhibit of Messrs. John I. Thornycroft and Company, Limited, Thornycroft House, Smith-square, London, S.W.1, is designed to illustrate the facilities provided for overseas consumers in the way of marine internal-combustion engines of different types. There are several new models to be seen, though space only permits the illustration of one of them. This engine is illustrated in Figs. 46 to 48, page 228, and is of considerable interest, particularly from the fact that it is fitted with a self-changing reverse gear which greatly simplifies manœuvring. The ahead and astern gearbox is seen to the right of Fig. 46, though some of the details do not appear in this view. These are shown, however, in the enlarged view of Fig. 47. The reverse gear comprises a multi-plate friction clutch for ahead and a cone clutch and epicyclic gear for astern; both gears are oil-actuated. The control is by the selector valve seen on the gearcase at the bottom left-hand corner of Fig. 47, which is actuated by the small lever, with a knobbed end, visible towards the centre. This lever also controls the injection pump by means of the shaft seen just behind the gauge board. This double control, which is covered by Thornycroft patents, has the advantages that it is light to operate and that the engine is automatically slowed down before either clutch can be disengaged. With the lever in the position shown in Fig. 47, the engine runs in the one direction, depending on the "handing" of the propeller. When it is turned anti-clockwise to the horizontal position, the clutches are both disengaged, the engine idles and the propeller is stationary. When the lever is turned vertically downwards, the engine runs in the other direction. As shown in Fig. 47, the control position is aft of the engine, but, obviously, it is a simple matter to arrange remote control from any part of the craft, as only a small and easily-operated lever is involved.

The engine, as shown in Fig. 46, has six cylinders, 4½ in. bore by 6 in. stroke. For continuous duty in heavy craft it is recommended to be run at 1,200 r.p.m., when 600 brake horse-power is developed. For medium duty in passenger boats, yachts, etc., the speed may be 1,500 r.p.m. with 75 b.h.p., while for such craft as fast launches, in which intermittent bursts of high speed are required, the engine can be constructed to run at 1,600 r.p.m., with an output of 90 b.h.p. These figures are for an engine without reducing gear. The engine operates on the four-stroke cycle with direct injection; the combustion chamber is formed in the top of the piston, which results in economy of fuel and easy starting. The engine is designed to use light Diesel oil and the consumption per hour, at 75 brake horse-power, is approximately 3¾ gallons. Injection is by a C.A.V. pump driven by the timing chain and spur gears. Fuel delivery is regulated by a governor at maximum and idling speeds, in addition to the manual control mentioned above. C.A.V. multi-hole injectors are fitted. The starting gear is of the C.A.V. 24-volt type, the dynamo being driven from the timing chain through a flexible coupling. The starting motor, of the axial type, engages with a toothed ring on the flywheel. The dynamo has an output of 288 watts and the capacity of the battery is 78 ampere-hours. The general lay-out of the engine is seen in Fig. 46. For cooling-water circulation there is a gear-type pump at the forward end of the engine, driven at half crankshaft speed. There is a rotary bilge pump at this end and, low down in the crankcase, a rotary gear pump for the forced-feed lubrication system, which includes an oil cooler and strainers.

The cylinders are of monobloc design cast in Chromidium and combined with the upper half of the crankcase. Dry liners are fitted to the cylinder bores. There are two cylinder heads, each containing three sets of air and exhaust valves, which are operated from a camshaft, with integral cams, carried in a tunnel high up in the crankcase and driven from the crankshaft by a duplex roller chain with automatic tensioning device. The air inlet manifold is an aluminium casting which carries an air silencer. The water-jacketed exhaust manifolds seen in Fig. 46 are of cast iron. A spray-cooled silencer can be fitted at the forward end; this is not shown in Fig. 46, but when it is supplied the height of the engine over it is 42½ in. from the top of the engine bearers, while the crankcase sump projects

11¾ in. below that level. The forward end of the crankshaft carries a hand starting lever as shown; the overall length of the engine measured from this lever to the output shaft flange is 85 in. The width over the bearer flanges is 28 in. Optional fittings are a power take-off at the forward end and a reducing gear, of 2 to 1 or 3 to 1 ratio, at the after end. The engine is classified by the makers as the RNR.6. The reverse gear, which is supplied to Messrs. Thornycroft by the Self-Changing Gear Company, Limited, Lythalls-lane, Coventry, is illustrated externally in Figs. 46 and 47, and in section in Fig. 48. In addition to appearing on the engine on Messrs. Thornycroft's stand, an example of the gear, with the outer casing made in a transparent plastic material, so that the mechanism is visible, can be examined on the stand of the Self-changing Gear Company.

Fig. 48, which shows the mechanism of the self-changing reverse gear, is drawn with the clutch elements in the neutral position, that is, with the engine idling and the propeller stationary. The crankshaft is indicated at *a*, its flange being formed with a labyrinth-type periphery in the opening of the gear case. The flywheel, indicated at *b*, is clamped by means of through set pins to the crankshaft flange and to the flange of the driving shaft *c*. To the larger diameter of this shaft is secured the end of the clutch drum *d*, which is connected to the drum by spline-like projections to provide freedom of axial movement. The drum houses the multi-plate ahead clutch, one set of plates being carried on the inside of it and the other on a centre on the splined driven shaft. The plates are compressed for engagement by the sliding pressure-plate *e*; they are shown as being not in contact, there being springs, not illustrated, between the plates, maintaining the open position when the pressure on plate *e* is removed. Between the pressure plate and the planet carrier-plate which forms the cover of the drum is a diaphragm *f*. The planet carrier-plate is indicated at *g*, and one of the planet wheels at *h*, with a link plate at *i*. It will be noted that the planet wheel shown does not engage with the sun wheel *j*, this latter wheel being carried on the splined driven shaft *k*, which is fitted with the coupling *l*, for attachment to the propeller shaft. The thrust of the propeller shaft is taken by the ball race *m*. On bushes on the driven shaft, so that it is free to rotate on that shaft, is the cone-wheel *n*, the periphery of this wheel being shown clear of the friction ring *o*, attached to the gear casing. The planet wheels are in pairs, that is, the wheel *h* in mesh with the toothed ring of cone wheel *n* is also in mesh with a second planet wheel, carried on the swinging link *i* and not shown, this secondary planet wheel being also in mesh with the sun wheel *o*; in this way there is a positive connection between the planet carrier, the cone wheel and the sun wheel.

At this point it is desirable to consider the operation of the gear along with its construction. The movements of the clutches are, as stated, actuated by oil pressure, derived from the gear pump *p*, driven from the end of the drum *d*. The pressure oil is directed to the various points by an ingenious control valve, which, although omitted for the sake of clearance from Fig. 48, can be seen in the left-hand bottom corner of Fig. 47, where it can be identified by its horizontal lever and the linkage connecting that lever with the vertical ball-ended control lever, which also controls the engine throttle. The control valve is oscillated on a vertical axis and is formed with a number of ports which are connected by passages in the gearcase and cover with the points to be fed or exhausted and with the pump *p*. Since all the oil, whether used for clutch operation or lubrication, is returned to the gearcase sump, the pump suction is led to the interior of the filter *q*. There is also a gauze filter on the pump delivery, not shown in Fig. 48. It will be noticed from this illustration that the driven shaft *k* has a central hole with radiating ports. A pair of these ports are in line with the opening *r*, which is separated from other passages by packing rings on the muff surrounding a liner on shaft *k*. When it is desired to give ahead rotation to the propeller, the control valve is turned so as to admit pressure oil to the port *r*. This oil flows along the central hole and out, through another pair of radiating ports, into the spaces between the boss of the pressure plate *e* and the left-hand side of the diaphragm *f* when a certain amount of pressure develops to engage the clutch plates. This compressing action is not, however, all that takes place.

It will be noticed that the planet carrier plate *g* is fitted with, between two of the pairs of planets, a spring-loaded piston valve *t*. As drawn in Fig. 48, in which the gear is seen in the neutral position, the plates are open and the stream of oil for lubrication, which flows over them, finds its way by centrifugal action round the edge of the diaphragm plate and then through port *u* and the annular space of the valve *t*, to escape finally to the sump through port *u'*. But, as the plate-closing pressure builds up, the valve *t* is forced to the right, so that the port *u* is opened past the end of the valve and the pressure oil passes through that port and round the periphery of the pressure plate *e* into the chamber *v*. The whole area of the pressure plate is then subjected to oil pressure and the clutch plates are held with the necessary degree of friction to give the torque for ahead rotation of the driven shaft *k*. The planets are, of course, merely idling. When it is desired to rotate the shaft in the astern direction, the control-valve lever is rotated to cut off pressure at *r* and to admit it into the space *w*. This is followed by a movement to the left of the sliding cone-wheel *n*, the periphery of the wheel being forced into contact with the friction ring *o* by the pressure of the oil in the space *x* over the whole surface of the wheel. The cone-wheel is thus rigidly locked and the crankshaft torque is transmitted through the planets to the sun wheel *j* and the shaft *k*. The cessation of the astern rotation and the restoration of the ahead rotation involves the passage through the neutral position and, accompanying this, there is a rapid evacuation of the pressure oil in the space *x* through a uni-directional release valve to the sump; this valve is not shown in Fig. 48.

In the neutral position, oil is admitted to the space *y* and flows along the spline spaces to lubricate such parts as the planets and clutch plates; the appropriate ports are shown in Fig. 48. Operation of the control valve for ahead and astern rotation does not cut off the oil circulation for lubrication; this goes on throughout the idling of the engine, the ports in the control valve merely directing the different flows. The ball bearings, for example, are continuously lubricated, the passage for the return of the oil to the sump being clearly seen in the right hand lower part of Fig. 48. The passage *z* in this area is one of the connections to the control valve. Though the whole of the ports and some other small details cannot be shown in the single view of Fig. 48, the gear is shown substantially as fitted to the RNR.6 engine, the elucidation or general principles of operation rather than precise details of construction being what is aimed at in this illustration. There is, however, one point which calls for comment. The control valve embodies an automatic spring-loaded device, the function of which is as follows. When the pump delivers more oil than is required for clutch operation, the oil pressure will tend to rise above the pre-set figure of approximately 60 lb. per square inch. At this pressure the device will operate against its spring until oil escapes into the lubricating system of the gearbox. If, in spite of this relief, the device provides more oil than is needed for lubrication, the surplus passes into the gearbox sump.

Among the other exhibits on Messrs. Thornycroft's stand, there is an example of an RNR.6 engine driving an alternator and arranged as a portable generating set on bedplate skids. The output is 27½ kVA at 1,000 r.p.m., the current being three-phase, 50 cycles, 346 volts. There is a two-cylinder 15/18 brake horse-power Diesel engine with self-contained reducing gear, and post-war examples of the firm's four-cylinder and six-cylinder Diesel engines of 30/40 brake horse-power and 60/65 brake horse-power, respectively. These engines are all made at the firm's Reading works, where much experimental work has been done on the Meteor 570 h.p. petrol engine for marine work; this is the un-supercharged conversion of the Rolls-Royce Merlin aero engine now being built by the Rover Company, Limited, at their Acocks Green factory, but of which the sole world selling rights have been acquired by Messrs. Thornycroft. Illustrated, by data, on the stand is the Thornycroft marine conversion of the Ford V.8 petrol engine, developing 78/73 brake horse-power at 2,800/3,200 r.p.m. This engine was employed to a considerable extent in fast naval launches during the war and is now offered for commercial and pleasure craft of the lighter classes.

An exhibit of a process which was employed extensively during the recent war, but of which details were withheld during that period, is the method of electrically welding studs, pins, lugs, etc., to steel plate. This exhibit is on the stand of Messrs. Cyc-Arc Stud Welding, 27/29, New North-road, London, N.1, and was fully described and illustrated in the issue of ENGINEERING for March 28, 1947, on page 234. The process is particularly useful for attachments in places where the steel plate is not to be perforated. Apart from this, it entirely dispenses with drilling, tapping and other operations and enables the studs, etc., to be welded in place with a high degree of accuracy of position. Brass studs from ⅛ in. to ¾ in. in diameter and steel studs from ⅛ in. to ⅞ in. in diameter can be effectively welded to mild steel, chrome steel, armour plate, etc., at a rate ranging from 180 to 500 studs per hour, according to their diameter.

Among the display of speed and revolution indicators and other instruments on the stand of Messrs. Smiths Industrial Instruments, Limited, Cricklewood Works, London, N.W.2, were examples of the hand tachometer illustrated and described in ENGINEERING, vol. 160, page 186 (1945). This interesting instrument is of the magnetic type, the rotation of the spindle being translated into a dial-reading of revolutions per minute by the interposition of a rotating permanent magnet which sets up a field controlling the movements of the dial pointer. A range of speeds between zero and 50,000 r.p.m. in either direction of rotation is provided, with a guaranteed accuracy within 0·5 per cent. Other speed and revolution indicators, including railway speed indicators, are for permanent attachment and not for hand use; they are in some cases of the magnetic, and in other cases, of the electric type. There are also shown counting devices; pressure, vacuum and compound gauges; escapements and a variety of instruments the construction of which calls for a high degree of workmanship and precision.

A new product to be seen on the stand of Messrs. G. A. Harvey and Company (London), Limited, Greenwich Metal Works, London, S.E.7, is an improvement on the old type of gilled tube in which the gills are formed by winding a thin flat strip of metal, edge on, helically on to the tube, the difference in circumference between the inner and outer edges of the strip causing the inner edge to assume a crimped form, which keeps it in place on the tube; the winding is done cold. In the new tube, the strip is tapered in cross section, that is, it is twice as thick at the inner edge in contact with the tube as it is at the outer edge. This wider base gives the supporting effect of the crimping of the parallel strip while, since the helical winding is done while the strip is at a cherry-red temperature and the strip contracts on cooling, contact between the tube and the gill is very complete. The net result of these two differences is, it is claimed, to increase the efficiency, or rate of heat transfer, by approximately 25 per cent. compared with the parallel-strip gilled tube. The new tubes are manufactured in a variety of sizes from 1 in. to 4½ in. in outside diameter, the gills varying, according to diameter, from ⅜ in. to 1½ in. in depth. The pitch of the helix also varies with the diameter, that is, there are from 14 gills to 48 gills per foot length of tube. The length of gilled tube may be anything up to 22 ft. Apart from this specifically new product, developments made by the firm since 1939, when considerable extensions and improvements were effected, are evident from examples of work displayed on the stand. Prominent among these is a steel dished end plate made by the "Rotarprest" process, the diameter of the original steel blank, being 12 ft. 9 in. and the thickness 2¼ in.; the finished weight is 5½ tons. There are examples of fabricated welded

EQUIPMENT FOR CLEANING TUBE TRAINS.

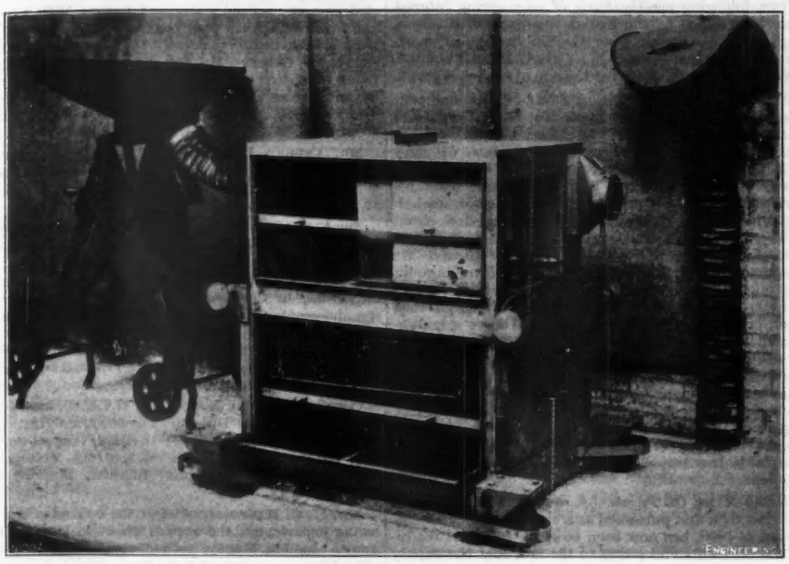


FIG. 1. DUST EXTRACTOR AND ACCESSORIES.

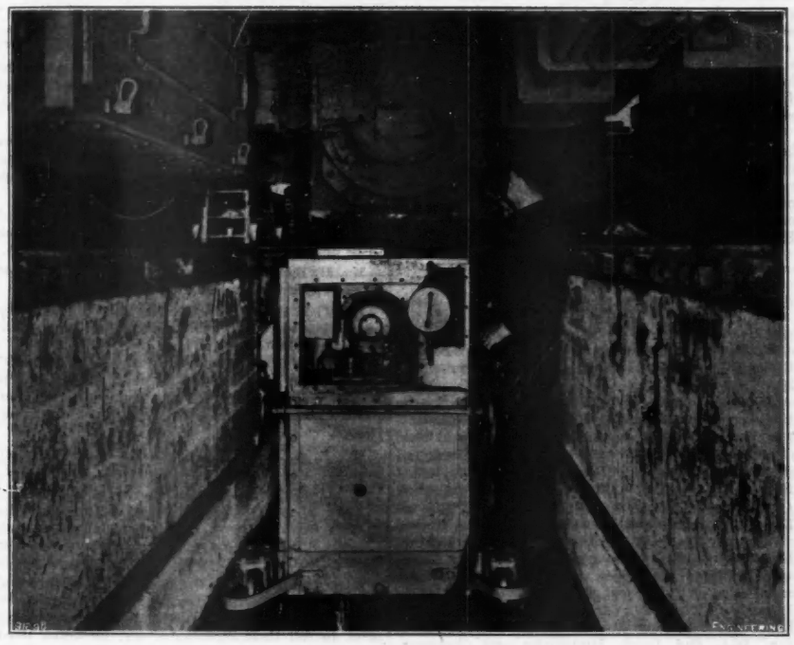


FIG. 2. DUST EXTRACTOR IN USE.

work, with photographic illustrations of some heavy pressure vessels so constructed. Some of the work of the firm in perforated material is illustrated by actual examples. The great variety of perforation in metals of various kinds and thicknesses has long been known, but perhaps the full extent of the range is not so generally appreciated. The fact, however, that slots measuring $1\frac{1}{2}$ in. by $\frac{3}{8}$ in. can be punched through mild steel $\frac{1}{8}$ in. thick, while holes as small as 0·015 in. in diameter can also be punched, though, of course, in thinner metal, shows that the technique of perforation by punching is not confined to sheets for ornamental screening only.

A new development in one of the products of Sir George Godfrey and Partners, Limited, Hampton-road, Hanworth, Middlesex, is a range of Marshall Roots blowers, which has been designed and produced since the war as a result of the firm's experience in the manufacture of aircraft cabin blowers for fighter aircraft. This new type of industrial blower is thus a less bulky unit than the machine that formerly obtained. The rotors are of the three-bladed type and of involute contour; they are normally made of light alloy with shafts of high tensile steel. The capacity of the new "M" range varies, according to size, from 5 litres to 20 litres swept volume per revolution.

(To be continued.)

SALE OF MACHINERY IN SCOTLAND.—An auction is to be held at the Motherwell depot of the Ministry of Supply on September 16. The items to be offered include baling presses and stackers. Catalogues may be obtained from the auctioneers, Messrs. J. and J. Marshall, Limited, 40, Cassells-street, Carluke, Lanarkshire.

CLEANING ELECTRICAL MACHINERY ON TUBE TRAINS.

THE London Passenger Transport Board, in co-operation with Messrs. Dallow, Lambert and Company, Limited, of Spalding-street, Leicester, have recently developed a satisfactory method of removing the dust which becomes packed in the ventilating ducts of Metadyne machines and motor-generators on their rolling stock. The dust, which may cause over-heating or upset the balance of the rotor, was previously removed by blowing with compressed air, but this was unsatisfactory, because the dust was scattered and not collected. Although, with the new method, the dust is blown by compressed air, it is collected by an extractor, working on the vacuum-cleaner principle; this is illustrated in Fig. 1, on this page, with its covers removed, together with two flexible hoses. The left-hand hose is provided with a funnel to connect to the air exhaust duct of a Metadyne machine, and the right-hand hose, shown standing against a wall, is fitted with a hood which is secured by cords to the motor-generator to be cleaned. Fig. 2 shows an operator directing a jet of air, from the shop compressed-air line, into a Metadyne machine, while the extractor sucks the dust out at the farther end.

The extractor is supported on four wheels and is normally used in the pit at the Board's Neasden depot, where cars are brought for cleaning. At one end of the upper half of the extractor, a 1-h.p. motor (which may be seen in Fig. 2, together with the starting gear) drives the vacuum fan which is connected to the lower chamber of the extractor. The lower chamber contains a filter consisting of 25 bags stuffed with sisal grass, which separate the dust from the air stream. When the filter bags become impregnated with dust, they are cleaned by agitating them with a rod which is permanently connected to the extractor for this purpose. The dust is allowed to settle in a removable tray at the bottom of the chamber.

The particular flexible hose in use is connected to one or other of the two inlets to the extractor, which are situated one at each end and communicate with the lower chamber. One of these inlets, blanked off, may be seen in Figs. 1 and 2; and in Fig. 1, the Metadyne-machine flexible hose is shown connected to the other inlet. The funnel and hose are supported on a scissors-type elevator, placed in the pit, which may be raised or lowered by turning a handwheel. The air from the extractor, after being cleaned, is blown out through an opening in the top of the extractor. The current for the fan motor is taken from the 600-volt direct-current overhead trolley circuit in the shop, and is fed to iron-clad switch-controlled sockets situated at intervals along the pit wall. The extractor case is 2 ft. 4 in. in width, 3 ft. 1 in. in length, and 4 ft. high.

LECTURES ON STEAM AND ON REFRACTORIES.

A COURSE of twenty-seven lectures on "Fuel Economy in Relation to Steam Generation and Steam Utilisation," will be given this winter in the Department of Applied Chemistry at the Northampton Polytechnic, St. John-street, London, E.C.1. The course is divided up into three sections, of which the first, section A, will consist of seven lectures, on "The Principles of Combustion and the Properties of Steam," to be delivered by Mr. G. F. J. Murray, B.Sc., A.M.I.C.E., A.M.I.Mech.E., at 7 p.m., on Tuesday evenings, commencing on October 7. Section B, which will cover "Steam Generation," will consist of ten lectures to be delivered by Mr. C. J. Hasler, B.Sc., Mr. G. F. J. Murray, and Mr. A. W. M. Somerville, A.M.I.E.E., F.Inst.F., at 7 p.m., on Tuesday evenings, commencing on November 25. Section C, which will deal with "Steam Utilisation," will also consist of ten lectures, to be delivered by Mr. D. L. Copp, A.M.I.C.E., A.M.Inst.Gas E., at 7 p.m., on Thursday evenings, commencing on November 27. The fee for section A is 10*s.*, and that for each of sections B and C, 12*s.* 6*d.*

Another course of ten lectures to be given in the Department of Applied Chemistry of the Northampton Polytechnic will concern "Refractories, their Production, Properties and Uses." The lecturer will be Mr. L. R. Barrett, B.A., B.Sc., and the course will commence at 7 p.m., on Wednesday, October 8, the remaining nine lectures being delivered at 7 p.m. on subsequent Wednesday evenings until December 10. The fee for this course is 12*s.* 6*d.* Admission to the courses is effected by personal enrolment at the office of the Northampton Polytechnic on any weekday between the hours of 10 a.m. and 7 p.m. Further particulars regarding the courses of lectures outlined may be obtained on application to Dr. J.E. Garside, M.Sc. Tech., A.R.I.C., head of the Department of Applied Chemistry of the Northampton Polytechnic, by letter at the address given above, or by telephone (CLErkenwell 1662.)

INSTITUTION ELECTIONS.

INSTITUTION OF MECHANICAL ENGINEERS.

Associate Member.—George William Crawford Allan, B.Sc. (Glas.), Ph.D. (Michigan), London, S.W.1; Albert Wilfred Allwood, M.Sc. (Bristol), Norwich; Harold Auger, London, W.1; Thomas George Barnbrook, Wolverhampton; Bernard Beard, Manchester; Robert Betts, Keighley; George Cedric Booth, Bolton; David Gregory Brown, B.Sc. (Manch.), London, S.W.1; James Campbell, B.Sc. (Edin.), Aberdeen; Captain Eric Arthur Carr-Hill, R.E., London, W.C.2; David Sibbering Charles, London, S.W.1; George Hugh Cooper, London, W.3; Percival Bernard Cross, Enfield, Middx.; Edward Walter Allan Croucher, Sevenoaks, Kent; George Woolliscroft Deakin, B.Sc. (Eng.) (Lond.), Stroud, Glos.; Frederick Henry Fielder, Glasgow, C.2; William Frazer, B.Sc. (Glas.), Glasgow, C.1; Louis Gill, Hebburn-on-Tyne, Co. Durham; Charles Leonard Hawkes, Chistlehurst, Kent; Kazimierz-Stefan Januszewski, Waltham Cross, Herts.; Ralph Henry Keen, Rugby; Leen Ludwig Levite, Dr.-Ing., Tel-Aviv, Palestine; Harry Lord, Bury, Lancs.; Clifford Breillat Manning, London, W.C.2; Captain Thomas Murphy, R.E., B.A.O.R.; James Laurence Ness, London, S.W.20; Alec Middleton Perry, B.Sc. (Eng.) (Lond.), London, S.E.17; Lt.-Comdr. (E) Arthur Neville Picton, R.N., Warrington, Lancs.; Thomas Benjamin Prew, Birmingham; Lieut. (E) John Douglas Robins, R.N., Newcastle-upon-Tyne; Harold Rogerson, M.B.E., Manchester; Ernest Rose, Manchester; William Coward Sharp, Billingham, Co. Durham; James Milliken Smethurst, London, E.C.1; Ronald Nicholas Forrest Smit, Cape Town; John Thomson, Georgetown, British Guiana; John Searle Webber, B.Sc. (Eng.) (Lond.), Teddington, Middx.; Comdr. (E) David Apthorp Williams, D.S.C., R.N., London, S.W.1; Lt.-Comdr. (E) Leslie Lloyd Williams, R.A.N., Sydney, N.S.W., Australia.

INSTITUTION OF STRUCTURAL ENGINEERS.

Member.—John Lochhead Adam, Glasgow; Ove Nyquist Arup, Virginia Water, Surrey; Edward Atkinson, Newcastle-upon-Tyne; Arthur George Brant, Buntingford, Herts.; Charles Herbert Clarke, Johannesburg, South Africa; Pierre Joseph Gerard, London; Maxwell Gibbs, California, U.S.A.; Sidney John Harrison, Calcutta; Ernest Owen Jones, Swansea; Ramanlal Chandulal Parikh, Baroda, India; David Lewis Richards, Swansea; Cecil Glascott Wise, Bromley, Kent.

Associate Member to Member.—Edward Eric Booker, Birmingham; John William Carswell, Ashtead, Surrey; Isaac Kursbatt, Oxford; Samuel Edward Meggitt, Ipswich; Harold Albert George Tattersill, Wembley Park, Middx.

Graduate to Member.—Sir Donald Coleman Bailey, Bournemouth.

Associate Member.—David Jack Anderson, Gorakhpur, India; Sidney Cyril Barkin, Wembley, Middx.; Sean Mackey, Middlesbrough; Ralph George Marrable, London; Sam Fletcher Townsend, Darlington; Richard Loughnan White, B.A.O.R.

Graduate to Associate Member.—William Brown, Middlesbrough; Thomas Ian Cameron, Strathaven, Lanarkshire; David Cohen, London; Frank Crowther, Sheffield; Leslie Harry Fitzwilliam, London; John Tacey Marshall, Middlesbrough; Bernard Geoffrey McIntee, London; James Richard Edward Taylor, Stratford-on-Avon, Warwickshire; John Thornton, Redcar, Yorks.

ELECTRIFICATION OF THE MILAN-DOMODOSSOLA RAILWAY: ERRATUM.—We regret that an error involving a decimal point has occurred in our article on the "Electrification of the Milan-Domodossola Railway," on page 189, *ante*. The statement that the gradients between Milan and Gallarate do not exceed 6 per cent. should, of course, read 0·6 per cent. Similarly, the figure for the gradients between Gallarate and Arona should read 1·2 per cent. and not 12 per cent.

THE LATE SIR HAROLD KENWARD.—We note with regret the sudden death of Sir Harold Leslie Kenward, which occurred on August 28 on the Queen Elizabeth while he was on his way to the United States and Canada on business. Sir Harold, who was buried at sea on August 29, which would have been his 53rd birthday, was director of distribution of the Dunlop Rubber Company, Limited, and had been connected with the firm for 36 years. He was a member of the Government's Rubber Consultative Committee and had been prominently associated with the rationing and supply of tyres for Service and civilian requirements during the years of rubber shortage. Sir Harold, who was President of the Tyre Manufacturers' Conference and jubilee year (1946) President of the Society of Motor Manufacturers and Traders, was knighted at the New Year, 1947, for his services to the Ministry of Supply in connection with the rubber-tyre industry.

BRITISH STANDARD SPECIFICATIONS.

THE following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, at the price quoted at the end of each paragraph.

Schedule of Carbon and Alloy Steels.—An amendment (No. 1) to S.T.A. Specification No. 5, "Schedule of Carbon and Alloy Steels," published for the Superintendent, Technical Applications of Metals, Ministry of Supply, by the British Standards Institution, has recently been issued. The amendment contains particulars of a newly-included low-alloy nickel-chromium steel for bars, billets and forgings, designated V9E. The percentage composition of the steel is as follows: carbon, 0·28 to 0·37; silicon, 0·10 to 0·35; manganese, 0·60 to 0·90; sulphur, 0·05 maximum; phosphorus, 0·05 maximum; nickel, 0·80 to 1·30; and chromium, 0·40 to 0·65. It is stipulated that when ordered as V9E/1 the steel shall have a molybdenum content of between 0·10 and 0·25 per cent. In addition to specifying the composition, the amendment contains data regarding the mechanical properties and heat-treatment of the steel, notes on welding operations and examples of typical applications. Copies of the amendment, which bears the reference No. PD 611, may be obtained, gratis, from the British Standards Institution, enclosing a stamped addressed envelope.

Ready-Mixed Oil Paints.—A revision of specification B.S. No. 929, first published as a war-emergency specification in 1940, has now been issued. It covers ready-mixed oil paints and owing to the fact that the supply of raw materials to the paint industry is, at present, more restricted than ever, particularly in regard to white pigment and linseed oil, the specification is still described as an emergency one. It contains clauses regulating the compositions of priming paint, undercoating paint, and finishing paint, while requirements in respect of the quality of all the materials employed are laid down. General clauses specify drying time, colour, opacity, finish and consistency, and also fastness to light, water content, flash point and keeping qualities. Directions on sampling technique and on the methods to be used for conducting the various tests are contained in a series of appendices. Consideration is being given to the preparation of performance specifications for "oil-paint processes" using the types of paint provided for in the present specification, but until such specifications are available the present, B.S. No. 929, will remain in force. [Price 2*s.* 6*d.*, postage included.]

BOOKS RECEIVED.

Eccles Has a Jubilee. A Review of the 25 Years' Growth of Eccles (Birmingham) Limited. By DUDLEY NOBLE. Eccles (Birmingham) Limited, Strichley, Birmingham 30.

The Institution of Civil Engineers. An Introduction to Engineering Economics for Civil Engineering Students. The Secretary, The Institution of Civil Engineers, Great George-street, Westminster, S.W.1. [Price 1*s.*]

Yale University Bureau of Highway Traffic. Technical Report No. 1. *Traffic Performance at Urban Street Intersections.* By DR. BRUCE D. GREENSHIELDS, DONALD SCHAPIRO and ELROY L. ERICKSEN. Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven, Conn., U.S.A.

Modern Building Techniques. Bulletin No. 1. *Theory and Design of Cylindrical Shell Structures.* By R. S. JENKINS. The O.N. Arup Group of Consulting Engineers, Colquhoun House, Broadwick-street, London, W.1, and Lund, Humphries and Company, Limited, 12, Bedford-square, London, W.C.1. [Price 21*s.*]

British Coaster, 1939-1945. The Official Story. Prepared for the Ministry of Transport by the Central Office of Information. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net.]

Locomotion Papers. No. 1. *The Alford and Sutton Tramway.* By GEORGE DOW. The Oakwood Press, 30, White Horse-hill, Chislehurst, Kent. [Price 2*s.* 6*d.*]

German Research in World War II. An Analysis of the Conduct of Research. By COLONEL LESLIE E. SIMON. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 4 dols.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 24*s.* net.]

Frequency Modulation Engineering. By CHRISTOPHER E. TIBBS. Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 28*s.* net.]

Industrial Apprenticeship. By PAUL BERGEVIN. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 2·75 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 14*s.*]

PERSONAL.

MR. E. W. SENIOR, chairman and joint managing director of Messrs. George Senior and Sons, Limited, and chairman of Sheffield Forge and Rolling Mills, Limited, and other firms, has been elected by the Cutlers' Company of Hallamshire to succeed the HON. R. A. BALFOUR as Master Cutler. He will be installed in October. Other newly-elected officers include MR. J. P. HUNT as Senior Warden; MR. W. R. S. STEPHENSON as Junior Warden; MR. W. G. IBBERSON as Searcher; and the HON. R. A. BALFOUR as Assistant Searcher.

MR. ANDREW HENDERSON, M.I.E.E., superintendent electrical engineer, Canadian Pacific Steamship, Limited, is retiring. He will be succeeded by MR. F. W. EVANS, at present assistant electrical engineer.

SIR ALEXANDER DUNBAR has joined the board of the Projectile and Engineering Company, Limited, Acre-street, Battersea, London, S.W.8.

The President of the Transport Arbitration Tribunal, established by Section 105 of the Transport Act, 1947 (for proceedings other than Scottish proceedings) is MR. C. MONTGOMERY WHITE, K.C. The President of the Tribunal (for Scottish proceedings) is MR. C. W. G. GUEST, K.C. The members of the Tribunal are MR. B. G. CATTERNS and SIR RUSSELL KETTLE.

COLONEL C. H. DE NORDWALL, M.I.E.E., has resigned his appointment as Director, Electrical and Instrument Equipment Branch, Industry Division, Control Commission for Germany, and has rejoined the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17.

MR. H. C. HASTINGS, chief of the control-gear engineering department, the British Thomson-Houston Company, Limited, Rugby, retired at the end of August, after 49 years' service with the firm. MR. C. J. SARJEANT has been appointed to succeed Mr. Hastings.

MR. A. BURTON STIBBON, formerly engineer, surveyor and town-planning officer to the Urban District Council of Cheshunt, has been appointed technical officer of the National Housing and Town Planning Council, 42, Devonshire-street, London, W.1. (Telephone WELbeck 8440.)

DR. FRED JOHNSON, who has been head of the Metallurgy Department, Birmingham Central Technical College, Suffolk-street, Birmingham, since 1912, is retiring.

DR. R. V. RILEY has been appointed research manager, foundries, at the Staveley, Bradley and Foster research department of the Staveley Coal and Iron Company, Limited, near Chesterfield.

MR. A. I. MACMILLAN, district engineer, London Midland and Scottish Railway, Irvine, has been appointed to be district engineer, Crewe, as from September 1.

MR. H. HENDERSON has been elected chairman of the Foamed Slag Producers Federation.

MR. T. E. WALLER has been appointed deputy district manager of the Nottingham depot of the Dunlop Rubber Company, Limited.

MR. NOEL CARRINGTON, director of Royle Publications, Limited, and MR. C. K. F. HAGUE, managing director of Messrs. Babcock and Wilcox, Limited, have been appointed additional members of the Council of Industrial Design.

MR. E. A. DAVIES has been elected President of the Swansea and District Metallurgical Society for the 1947-1948 session.

After 27 years' association with Croydon Airport, K.L.M. ROYAL DUTCH AIRLINES, 202-4, Sloane-street, London, S.W.1, transferred the operation of their London services to London Airport (Heathrow) on September 1.

ASSOCIATED BRITISH OIL ENGINES, LIMITED, Duke's-court, 32, Duke-street, London, S.W.1, announce that the board of LAGONDA LIMITED, have reached an agreement to sell their Staines factory, including buildings and machinery, to a group headed by MR. ALAN P. GOOD. The group will use the factory primarily for the manufacture of a new range of oil engines.

A new company, MESSRS. KELVIN AND HUGHES, LIMITED, has been registered to acquire the issued capitals of MESSRS. KELVIN, BOTTOMLEY AND BAIRD, LIMITED, and MESSRS. HENRY HUGHES AND SON, LIMITED. The chairman of the new company is SIR FREDERICK C. STEWART, D.L., LL.D., J.P., the deputy chairman, SIR ALLAN GORDON-SMITH, K.B.E., D.L., the joint managing directors MR. F. A. KING, A.M.I.E.E., A.F.R.Ae.S., and MR. G. B. G. POTTER, B.Sc., M.I.Mech.E., A.F.R.Ae.S., and the other directors MESSRS. RALPH GORDON-SMITH, MR. W. T. SLATER, M.Sc., A.F.R.Ae.S., and MR. A. J. HUGHES, O.B.E., F.R.Ae.S.

MESSRS. THE STAVELEY COAL AND IRON COMPANY, LIMITED, near Chesterfield, have acquired the whole of the shares in BESWICK'S LIMEWORKS, LIMITED, Hindlow, near Buxton. The board of the company has been reconstituted. MR. T. A. MCKENNA is chairman, MR. P. J. BESWICK is managing director, and MR. J. D. BERRESFORD, MR. G. W. P. BESWICK and MR. S. N. TURNER are directors.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Outputs are still running at nearly 100 per cent. of effective capacity despite the continued hot weather, which makes the lot of the steelworker unpleasant. In the rolling departments, some time has been lost due to the oppressive heat, so that the performances of the smelters must be highly commended. The demand for plates and sections is unabated, and sizes between $\frac{1}{16}$ in. and $\frac{1}{4}$ in. thick are extremely difficult to procure without long delays. Regular users, such as the shipyards, are getting a fair allocation against their authorisations, but ship-repairing is taking priority at the moment, so that repairs to ships are being effected with practically no delay. This policy seems sound, as steel so utilised can, ton for ton, do more to strengthen the capacity of the maritime carrying trade than steel employed for new construction. The main problem of the steelmakers is the acute shortage of scrap. Unless more scrap is forthcoming there is a real danger of output being curtailed; the extent to which makers can use greater quantities of pig iron is definitely limited at the moment. The new blast-furnace at Clyde Iron Works would contribute a substantial amount of pig iron, but it is still doubtful whether this third furnace will be able to get sufficient coke to keep it in steady production without interfering with the coke supplies of existing blast-furnace plants. The tube and sheet trades are both working steadily, but the demand still greatly exceeds outputs.

Scottish Coal.—There has been a slight improvement in the recent attendance figures of the collieries, but output is still only some 430,000 to 435,000 tons a week—or 70,000 below the short-term target agreed by the Scottish Conciliation Board, including the union members themselves. If the Scottish miners carry out their stated intention to work a six-day week for a temporary period, and if absenteeism can be brought back to the level of May last, the target would undoubtedly be attained. Stocks of coal are reported to be rising slowly all round, but the margin over last year is still far too low to justify any sort of complacency concerning winter fuel prospects. Export coal is still purely nominal. The demand for bunkers remains as vigorous as ever.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Supplies of pig-iron have been coming forward more freely as a result of more regular supplies of coke. Steel manufacturers are much concerned about the 4*s.* pit-head advance in coal prices and anticipate that steel prices will have to be advanced by some 8*s.* to 12*s.* per ton. Many makers of steel products fear that price advances will accelerate the disappearance of the sellers' market abroad. Effort is being made to arrive at methods of staggering hours suited to the steel and engineering trades when the proposed power cuts become operative in October. So far as electrically-melted steel is concerned, there is certain to be reduced production; at present, about 7,000 tons of special steels are melted each week in electric furnaces. One proposal being considered is that firms working day and night shifts should work their heaviest power-consuming plant at full capacity during "off-peak" hours and ease off at other times. This would bring about an extension of night work. Consideration has to be given to the fact that many firms in Sheffield are continuous-process firms with day and night shifts in operation. Some idea of the dependence of Sheffield industry upon electricity may be gained from the fact that one leading firm alone at its several works uses 80,000,000 units of electricity a year from the public supply. An experimental forge is in operation at the steelworks of Messrs. Daniel Doncaster and Son, Limited, designed to reduce the accident and sickness rate and improve conditions of work from the "hot and arduous" category, which makes recruitment of labour difficult. The walls are painted bright green and the furnaces blue. The floor is of blue brick and the whole building is spotlessly clean and cool. A special smoke trap takes fumes away from the hammer bay, and heat radiation is eliminated as the furnaces have been built at right angles to the bay. Shuttered walls designed on the Venetian blind principle afford good ventilation.

South Yorkshire Coal Trade.—Serious disturbance of the flow of supplies was caused by the numerous strikes of miners at pits where it was deemed desirable to register sympathy with the Grimethorpe men on strike against an extension of the "stint." The Grimethorpe men feared that their numbers would be reduced and surplus labour compulsorily removed to other collieries. It has been very difficult for allocators to ensure that high-priority users received adequate deliveries. No progress has been possible with the scheme of building up stocks of coal at industrial concerns, and there have been reductions in the despatches of house and gas coal. Demand for coke is strong, and patent fuel moves freely.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—The persistent demand for Welsh steam coals was being covered as well as possible again last week, but operators were facing an exceedingly difficult supply position. The level of output was fairly well maintained, but the scheme for the staggering of miners' holidays during the past two months has, of course, further limited supplies. At the same time, the expanding winter demand was being felt and there were special stocking programmes to be attended to, in addition to the normal trade, and operators had a hard task to keep pace with their commitments. All the fuel that could possibly be obtained was needed to satisfy inland needs, chief among which were those of the iron and steel industry, the railways, and gas and electricity stations. In this way, all the top qualities and the cheaper grades were heavily booked up for some while to come. There was a good trade offering in the foreign markets, but owing to the scarcity of coal no general export was allowed, and there was little shipment beyond that under special allocation for Eire and Canada. Cokes of all grades were heavily sold and supplies were short to meet a briskly sustained demand. A good interest continued to be shown for patent fuel which was actively engaged and firm. Four new opencast sites were scheduled for Wales, which would bring the number in the area up to eleven. Work in the iron and steel and allied trades of South Wales and Monmouthshire continued at a good level. Well-filled order books were held by most companies and there was no slackening of demand for steel products.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, business in tin-plate was quiet in regard to new commitments. This was due to the fact that makers had little to sell for the current period and consumers were awaiting their allocations for the last quarter. In the export market, the demand is maintained but only limited quantities have been released. There is a good demand for iron and steel scrap, the industry requiring more particularly the heavier and better grades.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The fuel situation continues to occasion grave anxiety. Recent events halted tonnage allocations to consumers and checked activity at plants turning out commodities urgently needed in large quantities for home purposes and for the export market. Supplies of coal and coke are precarious and early substantial increase in deliveries is necessary to enable essential attention to requirements for pressing home needs. For some time pig-iron production has fallen considerably short of users' requirements and the prospect of material expansion of output is somewhat remote. The make of all other descriptions of iron and steel may have to be curtailed to some considerable extent owing to the fuel shortage.

Foundry and Basic Iron.—The manufacture of ordinary Cleveland foundry pig iron was discontinued some time ago and the moderate parcels of blast-furnace products, high in phosphorus, that have been obtainable in recent months have been passing promptly into consumption at the steel furnaces. There is no basic iron for the market; all supplies are retained for consumption at maker's adjacent steel-producing plants.

Hematite, Low-Phosphorus and Refined Iron.—East Coast hematite manufacturers have a little iron in hand and at some consuming works small parcels are stored, but supplies are considerably below what could be wished. Available quantities of low and medium phosphorus grades of iron have, for some time, been on a scale inconveniently short of users' demands. Refined iron makers have only moderate tonnages for sale.

Manufactured Iron and Steel.—Semi-finished and finished iron and steel manufacturers have substantial contracts to carry out and steel producers have embarrassingly heavy bookings to execute. A substantial rise in steel prices became unavoidable in consequence of dearer coal and the prospective advance in railway rates at the beginning of next month. As approximately two tons of coal are consumed in the production of a ton of steel, the rise in the steelmakers' fuel bill is equal to 8*s.* A further upward movement in coal value is foreshadowed and the rise in railway rates next month will involve an extra charge of about 6*s.* per ton on finished steel. Thus, apart from advance in other production costs, steelmakers are confronted with an increase burden of at least 14*s.* per ton.

Scrap.—Pig-iron shortage has necessitated the exceptionally heavy consumption of cast-iron scrap and heavy steel scrap, large quantities of which have recently reached users' works.

NOTICES OF MEETINGS.

It is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTE OF ECONOMIC ENGINEERING.—*Midland Region:* Saturday, September 6, 2.30 p.m., Chamber of Commerce, Birmingham. "Planning of Mass Production," by Mr. J. Troth.

LONDON ASSOCIATION OF ENGINEERS.—Saturday, September 6, 6.30 p.m., Charing Cross Hotel, W.C.2. (i) "Estimating," by Mr. H. Byford. (ii) "The Installation of Plant and Machinery," by Mr. A. T. C. Whitaker.

INSTITUTION OF PRODUCTION ENGINEERS.—*Luton Section:* Monday, September 8, 7 p.m., Town Hall, Luton. Film Display by Mr. W. Whitworth Taylor.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, September 9, 5.30 p.m., 85, The Minories, E.C.3. (i) Presidential Address, by Sir Amos L. Ayre. (ii) "Steam Pipework Design in Ships," by Lieut. (E) P. T. Heath.

ROYAL AERONAUTICAL SOCIETY.—Tuesday, September 9, 7 p.m., for 7.30 p.m., Guildhall, E.C.2. Dinner in honour of the Anglo-American Aeronautical Conference.

INSTITUTION OF LOCOMOTIVE ENGINEERS.—Wednesday, September 10, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, Westminster, S.W.1. "The Westinghouse Empty and Load Brake with Straight Air Control: Its Installation, Operation and Maintenance," by Mr. Brian Fawcett.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midlands Students' Section:* Wednesday, September 10, 7 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address on "Insulation Engineering," by Mr. J. Wainwright.

INSTITUTE OF WELDING.—Addison Restaurant, Olympia, W.14. Autumn Meeting. Thursday, September 11, 2.30 p.m., "Welding in the Development of Jet Propulsion Engines," by Mr. H. E. Lardge. 5 p.m., "Some Novel Developments in the Design and Operation of A.C. Arc-Welding Plant," by Mr. E. C. Davies. Friday, September 12, 2.30 p.m., "The Development and Application of Stud Welding," by Mr. A. H. Bent. 5 p.m., "Some Aspects of Welding Repairs," by Mr. J. K. Johannesen.

FRENCH MOTOR-CAR INDUSTRY.—Figures published recently show that the French motor-car industry produced 70,500 vehicles, including 32,500 cars and 36,000 lorries, during the first six months of 1947. Exports totalled 42,000 vehicles. The figures for the corresponding period of 1946 were 42,000 vehicles produced, and 10,400 exported. It is added that a recent general increase of 25 per cent. in prices may affect future exports.

THE LATE MR. C. M. HILL.—It is with regret that we record the death of Mr. Clarence Mannings Hill, which occurred suddenly at Staines on August 18. Mr. Hill, who was 60 years of age, was a partner in the firm of Messrs. C. M. Hill and Company, railway engineers and steel agents, London, E.C.3, founded by him on his return from the 1914-18 war, during which he served in the Royal Army Service Corps, mostly in Salonika. He was also a partner in the firm of Messrs. Morrison, Marshall and Hill, electric crane and machine-tool engineers. Mr. Hill was well known in railway circles in London and Belgium.

THE ELECTRICITY ACT AND THE NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.—The Electricity Act of 1947, which received the Royal Assent on Wednesday, August 13, lays down that the North of Scotland Board is responsible for the generation, transmission and distribution of electricity in the North of Scotland district. This Board at present consists of a chairman, deputy-chairman and two members, but to bring it into line with the other Area Electricity Boards on the appointed day it will be enlarged by the appointment of a minimum of one or a maximum of five additional members. The chairman of the North of Scotland Board will also be an *ex-officio* member of the British Electricity Authority.

EXHIBITION OF INVENTIONS, BIRMINGHAM.—The Birmingham branch of the Society of Inventors are arranging to hold an exhibition of inventions in the late autumn. Manufacturers and private individuals will be able to exhibit, as well as members of the various branches of the Society throughout the country. To be eligible for exhibition an article must either be patented, protected, or of registered design. Drawings, models or replicas will be considered, and preference will be given to articles developed during, or since, the war. Intending exhibitors should write to Mr. B. Thornton Clark, 244, Stoney-lane, Yardley, Birmingham, 25, who should receive applications not later than September 15. Brief details of the article intended for exhibition should accompany the application.

EXHIBITS AT THE ENGINEERING AND MARINE EXHIBITION.

(*For Description, see page* 217.)

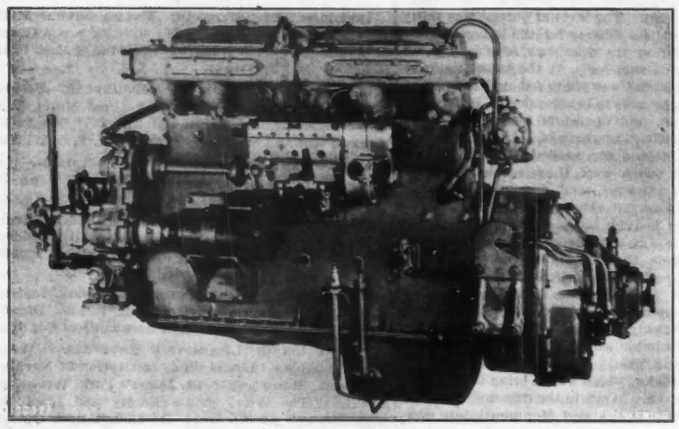


FIG. 46.

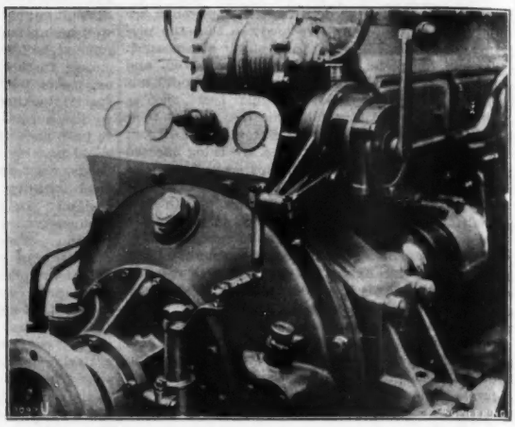
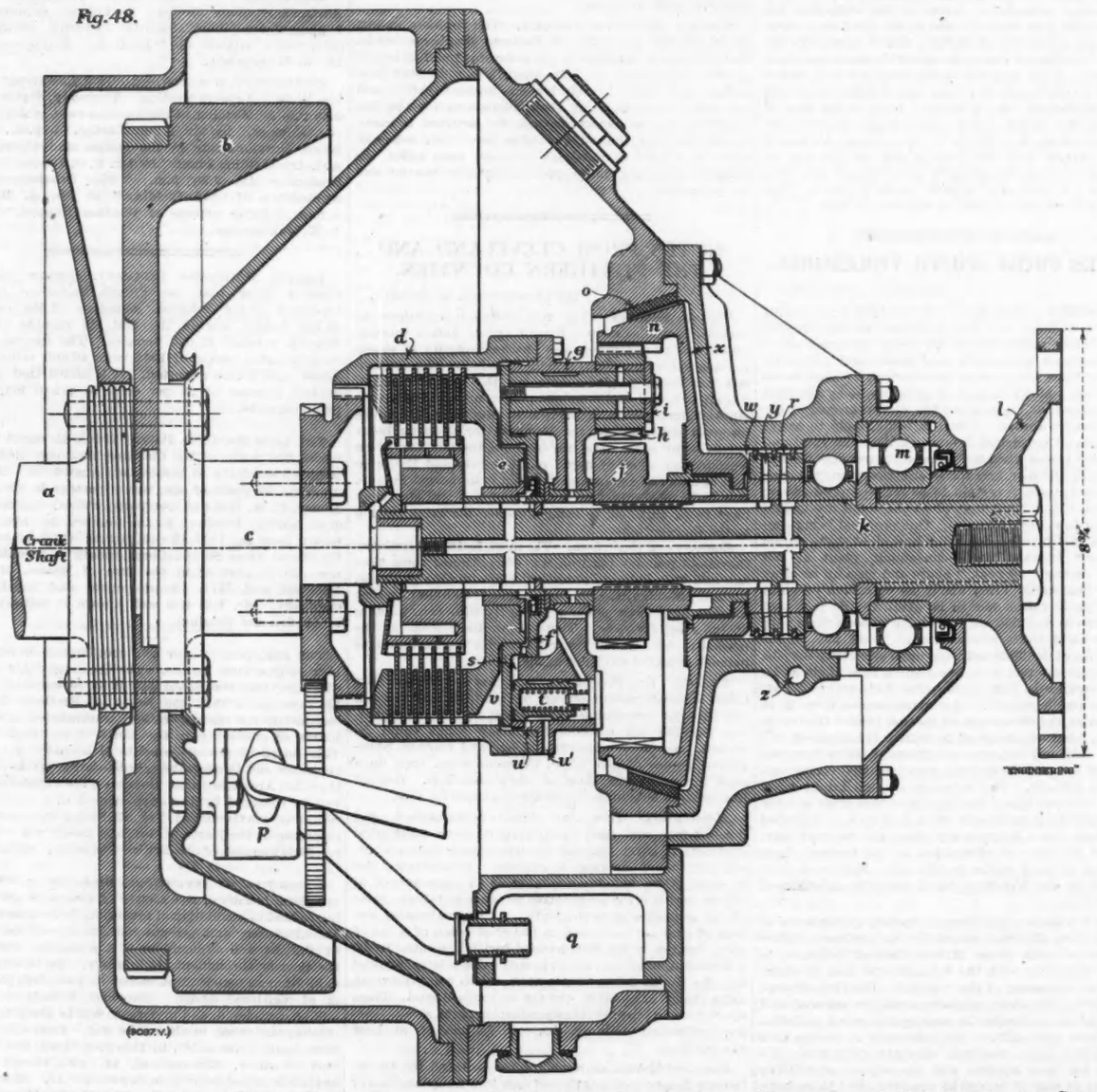


FIG. 47.

Fig. 48.



FIGS. 46 TO 48. SIX-CYLINDER MARINE DIESEL ENGINE WITH SELF-CHANGING REVERSE GEAR. MESSRS. JOHN I. THORNYCROFT AND COMPANY, LIMITED.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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SUBSCRIPTIONS.

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For Canada	£4 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements on the green art paper wrapper, on the inside black and white pages and in the buff art paper two-colour supplement, as well as for inserts, can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 8*s.* for the first four lines or under, and 2*s.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 24*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received at least 10 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, SEPTEMBER 5, 1947.

VOL. 164. No. 4258.

EXPENDITURE ON GOVERNMENT RESEARCH

THE growing recognition of scientific research and development as factors contributory to the security and prosperity of this country and its dominions is well exemplified by two bodies which came into existence at the beginning of this year, consequent upon the creation of the Ministry of Defence. They are the Defence Research Policy Committee and the Advisory Council on Scientific Policy, broadly concerned with military and civil problems, respectively, and replacing, on a wider peace-time basis, the Scientific Advisory Committee which fulfilled so valuable a function under the War Cabinet. A necessary link between these two new bodies is provided by the appointment of Sir Henry Tizard as the chairman, and Sir Edward Appleton as a member, of both; and there are numerous other connections between the main branches of the research structure as well as from each of them to the scientific activities of universities, learned societies, and technical or industrial institutions both at home and in the Dominions and Colonies. As commonly occurs in British institutions, the organisation of Government-sponsored scientific research has taken shape gradually to meet various needs as they have become apparent, but the resulting structure comprises at present a somewhat complicated assembly of responsibilities, more easily surveyed externally than from within.

Similar considerations apply to the task of reviewing the associated expenditure of public funds, estimated during the current financial year to exceed 75,000,000*l.* Not solely on account of the amount of money involved, but perhaps more to ensure that the most effective use is made of the national scientific effort, the Select Committee appointed to examine the Estimates presented to Parliament have made a thorough study of both the organisational and financial aspects and devoted to them a report* which is in some respects critical, on the whole approving, and always informative. It reveals, for example, that, of the total estimated expenditure, more than 60,000,000*l.* is allocated to the Admiralty and Ministry of Supply, and over 7,000,000*l.* to grants for scientific purposes in aid of universities and similar institutions. The Department of Scientific and Industrial Research gets, in round figures, three million pounds; industrial research by other Government Departments a million and a half; agriculture and fisheries, two millions; and the Post Office, three-quarters of a million. The remainder is shared by medical research, miscellaneous grants, and research in the Dominions and Colonies.

The Committee's general approval of this estimated expenditure is exemplified by their view that the value of research cannot be assessed in relation to savings in the cost of Government administration alone, but should take account also of savings to industry by increased competitive strength in foreign markets, by more effective use of manpower, or by the prevention of loss due to ill-health and agricultural pests. The potential, if uncertain, returns so greatly exceed the expenditure incurred that no country can afford to neglect either directed or fundamental research. It is interesting to note the Committee's view that pure research is a proper object for Government support through the medium of block grants to universities or even to individuals. The report goes so far, indeed, as to suggest that the current year's allotment towards the pursuit of fundamental knowledge and the provision of trained research workers is less than adequate, though it is probably as much as can be usefully and economically absorbed.

The implication here is clearly that the building shortage is hampering the training of scientists at universities and technological institutions in regard both to the housing of students and, to a less extent, the expansion of laboratory accommodation. In this connection, the Committee assert that the main source from which the Government service and industry can draw fully-qualified scientists must remain the universities; and that the provision of sufficient staff and accommodation for teaching and for the conduct of fundamental research would seem to be the foundation upon which the Government research programme must rest. Another aspect of the same difficulty is being encountered at new research establishments, to which staff cannot be attracted on account of the scarcity of suitable houses in the vicinity. While these are admittedly among the reasons why research and development are not advancing as rapidly as many think they should do, the Committee are additionally disturbed by the impression they have gained, from evidence put before them, that the conditions of Government service do not always create an atmosphere conducive to the achievement of scientific progress. Criticism has been levelled not so much against salary scales as against the deadening effect of departmental control and the restrictions of administrative routine.

Without admitting that such opinions are well-founded, the Committee advocate a greater degree of freedom for scientists in Government service to make personal outside contacts, and to exchange views and information with other workers in related fields. They go so far as to recommend interchanges of staff between Government departments and universities, substantially on the principle of the sabbatical year. The freshness of outlook implicit in such suggestions as these adds force to the Committee's concern at the serious delays in the construction of the new atomic-energy research station at Harwell. The matter is regarded the more seriously because of the widespread public interest, as well as better-informed technical interest, which the potentialities of controlled atomic fission have evoked: in which connection, the Select Committee consider that this is a subject on which the greatest amount of information, compatible with the interests of security, should be released to the public. They realise that the atomic-energy project opens up tremendous possibilities, not only for the generation of industrial heat and power, but also for the advancement of other physical research, the study of unsolved physiological and biological problems, and the provision of radio-active materials and separated isotopes for therapeutic purposes.

The four main parts of this programme require the construction at Harwell of two atomic piles. One of them, started up a week or two ago, is a relatively simple low-power pile for controlling the quantity of basic materials used, and for experi-

* *Expenditure on Research and Development.* Third Report from the Select Committee on Estimates. Published by H.M. Stationery Office, Kingsway, London, W.C.2. [Price 1*s.* 6*d.* net]

ments on the nuclear properties of elements. It consists of several hundred tons of very pure graphite into which is inserted a few tons of uranium metal, the whole being surrounded by a thick concrete shield. The second is to be a more elaborate pile, of higher power, to provide information requisite for the production of heat, power, and radio-active substances. In addition, the equipment will include mass spectroscopes, a 5,000,000-volt generator, and a large cyclotron.

With the intention of bringing this equipment, together with much elaborate ancillary plant and costly laboratories, into use by the summer of 1948, contracts for building and construction were let in April, 1946, and work was started on the site in the following month. It appears from the Select Committee's report that serious delays have occurred, only in part attributable to the prolonged bad weather of last winter, which must add materially to the original cost of the project and may have even more important long-term financial repercussions from the postponement of productive research. Remarking that they understand this project has the highest priority, the Committee express the view that this term is meaningless unless all structural supplies and accommodation for an expanding labour force are, in fact, provided, and they recommend that an immediate independent inquiry should be instituted into the organisation of the work.

The committee's severe, albeit constructive, criticism of the atomic-energy research programme has been influenced, no doubt, by the fact that, to produce conclusive results, expenditure for developments on an increasing scale must continue for an unspecified term of years, additional to the heavy and repeated costs incurred in the construction of pilot plants to investigate industrial and scientific applications. The project comes at present within the responsibility of the Ministry of Supply; and, while no separate monetary estimate for the atomic fission project is published in the report, it can be presumed, no doubt, that the immense sum involved goes some way to account for the unexpectedly large proportion of the total research estimates allocated to the Defence Services, in a year of peace, when emphasis everywhere is on the need for industrial expansion. The committee point out that, while the balance of the Government's research programme is a matter for judicious consideration, they are themselves unable, from the figures made available to them, to arrive at a fair estimate of the distribution of expenditure among the major classes of research. Nevertheless, some astonishment is expressed at the small figure allocated to forestry research, in view of the importance of forestry in the national economy and the many complex problems involved. Somewhat similar considerations apply to Colonial research, but are qualified by the recent promising activities of the Colonial Research Committee. The report suggests that existing arrangements for Colonial research expenditure have not been flexible enough to avoid wasteful delay and lost opportunities by establishments operating at great distances from the controlling authority, and recommends that more freedom of action should be granted to the officers responsible for work on Colonial sites.

Herein is exemplified a particular instance of the general principle, favoured by the Select Committee, that scientific research of high quality is not amenable to scrupulously precise systems of controlling and accounting for expenditure. So long as financial control of a general character is adequate to ensure the effective administration of public funds, the primary purpose of the scrutiny of estimates will be satisfied. That purpose would be valuably enhanced, from the standpoint of the general—and, more especially, the technical—public, by the issue of regular statements of the Government's research activities, so far as limits of security permit. The nationalisation of many industries, largely dependent on technology for their efficient working, must be accompanied by important future extensions of Governmental research in a number of new directions. It becomes of increasing urgency, therefore, that this principle of flexible control and administration should figure prominently among several farsighted suggestions of the committee which could, with advantage, be given practical effect.

THE NUFFIELD FOUNDATION.

WHETHER the increasing financial difficulties of the country will ultimately result in some reduction in the expenditure of public money on pure and applied research it is not possible to say. So far there has been no indication of any effect of this kind. Apart from the extensive programme of investigation in the field of atomic physics which has been put in hand, Government-sponsored research shows a tendency to increase in many other directions. Examples are furnished by the creation of a new establishment under the ægis of the Department of Scientific and Industrial Research to deal with problems of mechanical engineering and the decision to add an engineering section to the already wide field covered by the Water Pollution Research Board. A great deal has been heard from politicians and publicists about the importance of research for the future well-being and prosperity of the country, and although much of the exhortation may be based on very partial understanding of the subject concerned, the general point of view which it indicates is commendable as it shows a growing lay appreciation of the position which scientific work must take in industrial and social advance. It would, however, be highly undesirable if governmental and public enthusiasm resulted in the gradual monopolisation of scientific investigation by Government departments until a stage was reached at which all research workers were civil servants.

No one competent to express an opinion is likely to deprecate the work carried out by such bodies as the Department of Scientific and Industrial Research, or the National Institute of Agricultural Engineering, but it is more than doubtful if the quality and extent of that work are increased by the fact that in the long run the activities of these organisations are controlled by Treasury officials. The weakness necessarily inherent in the ultimate control of scientific bodies by lay authorities, which can have no proper understanding of their activities, which may appear unavoidable when public money is concerned, has to a considerable extent been eliminated by the admirable system of research associations to which public funds are allotted and which are left free to conduct their own affairs. The grants, however, come from the Department of Scientific and Industrial Research, which itself operates with a parliamentary grant. It is nominally free to expend that grant as may seem fit, but in practice it is very much a Government department, the activities of which are frequently controlled, it would not be an exaggeration to say hampered, by the procedure of the Ministry of Works and other Government bodies.

The scale on which research work is now being carried on in this country could not be maintained without the assistance of public money, but it is fortunate that at least some sections of that work are in the hands of organisations which owe allegiance to no official authority. An excellent example of such an organisation is furnished by the Nuffield Foundation, and the point of view advanced in the two preceding paragraphs is succinctly expressed in the second report of the Foundation, which has just been published. It states that "official resources are vaster, but non-official bodies enjoy, in some important ways, greater freedom of choice and action. Even the wisest and most knowledgeable authorities may err in their judgment of the possibilities of new ideas . . . it is to the public good that . . . there should be room for more than one opinion and for more than one means of putting that opinion to the test." In spite of this tribute to the value of independent action, the Foundation does not refuse to take advantage of such assistance in its work as may be furnished by co-operation with governmental and other official agencies.

As is well known, the main interest of Viscount Nuffield, outside his professional sphere, is concerned with medical research and services, and these constitute the first objects of the Foundation. The second clause in the statement of its purposes, however, contains the expression "scientific research and the organisation, development and improvement of technical and commercial education." Medical work lies in the main outside the sphere of interest of this journal, but scientific research and education, in the appropriate spheres, is directly its concern. It is stated in the report that a number of schemes "for help in the natural sciences" have been under review. From among them, extraction metallurgy has been selected for the purposes of a grant. This represents a field of work which officially-sponsored research has tended to neglect in favour of the study of alloys. This state of affairs may be attributed to the fact that extraction metallurgy, in many of its important aspects, cannot be studied in Great Britain. This, however, does not lessen the importance of the subject to the country and to many parts of the Commonwealth and Empire.

In drawing up a scheme for work in this field, the Foundation has had the advice and assistance of the Institution of Mining and Metallurgy, and it has been decided to establish a research fellowship for a period of five years as a starting point for a more permanent research organisation. Endowment will be on a scale enabling a team of workers, under a suitable leader, to be provided with any special apparatus and equipment required. Negotiations are being carried on, but have not yet reached a stage enabling the project to be put in hand. In the meantime, however, a series of travelling fellowships has been established to enable members of the teaching staffs of universities and approved schools of mines and metallurgy to visit mining and metallurgical centres in the long vacation. The value of a fellowship is 500*l.* and its tenure approximately three months. Post-graduate travelling scholarships are also available; these are of similar value and cover periods up to six months. A third grant covers vacation scholarships of 200*l.* for students to enable them to visit mining and metallurgical centres, at home or abroad.

There can be no doubt about the value of these various grants, but it would seem to be worth while considering if the period covered by some of the staff fellowships and post-graduate scholarships could not usefully be extended. The three-months' fellowships are intended to be held during the long vacation, but if in selected cases sabbatical leave could be arranged, it appears likely that more useful work might be done. The report states that of five holders of fellowships, four are utilising them in North America and one in South Africa. Three months is rather a brief period in which to get closely in touch with the details of a complicated industry in a new country. In the case of the post-graduate scholarship the argument in favour of the extension of the period covered seems even stronger, as the question of teaching commitments does not arise. This relative freedom has been recognised by making the period six months, but even that seems rather brief for "study in the Western Australian goldfields, and heavy steel industry, copper smelting and refinery in Tasmania," which is given in the report as the occupation of one of the graduate scholars this year.

Extraction metallurgy is not the only sphere of physical science which is being assisted by the Foundation. A number of grants, have been made to the physics departments of universities. In the case of the University of Birmingham, part of the grant has been used to obtain and develop special electronic equipment, which, however, is mainly provided by funds furnished by the Department of Scientific and Industrial Research, and most of the Foundation's grant has been used for the appointment of fellows. Two research fellows have also been appointed to Glasgow University, but the number is apparently to be increased as more equipment is provided, particularly the 300-million volt synchroton, for which the Department of Scientific and Industrial Research has furnished a capital grant. Fellows appointed to the bio-molecular laboratory of Birkbeck College are working at other establishments, such as the Royal Institution, pending the provision of a special college laboratory. Research fellows have also been appointed at Manchester, Oxford and Cambridge. In Manchester, part of the grant furnished has been utilised for the purchase of equipment.

THE BRITISH ASSOCIATION MEETING IN DUNDEE.

FOR the fourth time in its history, the British Association for the Advancement of Science has held its annual meeting in Dundee, the Association having met there this year from August 27 to September 3. In 1867, the Association met in Dundee under the presidency of the Duke of Buccleuch, F.R.S., P.C., and the next Dundee meeting was held in 1912, the President for that year's meeting having been Sir Edward Sharpey Schafer, F.R.S. The 1912 meeting was rendered notable by the generosity of the late Sir James Caird, a citizen of Dundee, who presented a sum of 11,000*l.* to the funds of the Association, and thus enabled it to commemorate his name in the Caird Fund, which is devoted to scientific research. The next meeting of the Association in Dundee was held in 1939, under the presidency of Sir Albert Seward, D.Sc., LL.D., F.R.S., at a time when war clouds were gathering fast. The meeting had, in fact, to be abandoned on the third day, when it became evident that war was inevitable. This year's meeting may, perhaps, be regarded as a resumption of the 1939 meeting, though it is obvious that there has never been such an "advancement of science" between two consecutive British Association meetings as has occurred between 1939 and 1947.

During the war, of course, science has been applied mainly to the production of new methods of offence and defence, but in order to emphasise the positive contribution of science to human progress in general, the Council of the Association decided that the programme of this, the first full post-war meeting, should conform to the general theme of "Swords into Ploughshares." The programme of lectures, papers and addresses therefore included a number of non-technical communications reviewing the achievements of science in war and its possibilities in peace, with discussions on a wide range of subjects of topical interest and importance to the general public, as well as to men of science.

While the main business of the British Association meetings is the reading and discussion of papers in the 13 sections, covering mathematics and physics, chemistry, geology, zoology, geography, economics, engineering, anthropology and archæology, physiology, psychology, botany, education and agriculture, into which the Association's work is divided, several functions of more general interest are held, and although we are unable to deal with them in detail, we propose to mention them briefly as an indication of the nature of the meetings. The first special function, on the morning of August 27, was the presentation of the Freedom of the City of Dundee to this year's President, Sir Henry Dale, O.M., G.B.E., F.R.S., the ceremony having been performed by the Lord Provost, Archibald Powrie. At the inaugural general meeting, held in the Caird Hall in the evening of the same day, Sir Henry delivered his presidential address, his subject being "Science in War and Peace."

In the first part of the address, he recalled the great scientific achievements during the war and referred to the fruitful collaboration between British and American engineers and physicists and to the possible applications of the results in peaceful pursuits. He pointed out that, in response to the demands of the war, the majority of the scientists of this country had devoted nearly the whole of their thoughts and efforts, over a period of six years or more, to practical problems presented to them for rapid solution. He thought, however, that our first care now should be the extension of fundamental knowledge, unconstrained by aim at any practical objective. He believed that research which sought only to advance pure knowledge commonly led in the end to the widest practical developments. Under the conditions now to be faced, he said, the building up of our scientific capital of fundamental knowledge by those who had the creative gift should have a prior claim over its practical exploitation and over any cultivation of its political influence.

He contrasted the parts played by science in the two world wars, pointing out that science had moved from the position of a mere accessory in the first war right into the centre of the picture in the war from which we had just emerged. The atomic bombs on Hiroshima and Nagasaki represented the immediately visible peak of this development: but nobody could suppose them to be the ultimate climax of disastrous achievement if the nations should persist in the desperate project of using further advances in this, or any other, department of science, to prepare in secret each to excel or anticipate others in perfecting means of annihilation. Scientists must proclaim the danger and their hatred of the perversion of science which this involved. He urged a resolute watchfulness against any encroachment, on activities proper to peace, of a secrecy accepted, as an abnormal condition, in war, and a determined effort to accelerate the liberation of science from all such entanglements. Sir Henry concluded by expressing the belief "that now, in a torn and groping world, we of this Association may need still to be on guard, lest some new and extraneous philosophy or political system, involving, perhaps, the authority of science to bolster its pretensions, may seek again to limit and to compromise, with a new orthodoxy, the freedom of science to seek and to proclaim such truth as it can discover, not as an expedient, but for its own beauty and for its beneficient promise to mankind."

At the conclusion of the address, the Lord Provost called on Sir James C. Irvine, F.R.S., Principal and Vice-Chancellor of the University of St. Andrews, to propose the vote of thanks. This was passed by acclamation, and, in acknowledging it, the President mentioned that the number of tickets issued for the meeting was 3,000. He also called attention to an appeal the Association was making for contributions to a development fund of 100,000*l.* for the advancement of science. The fund would be used, under the direction of the Council, for research work, the promotion of contacts between scientists, hospitality to young scientists, the provision of better accommodation than is possible at Burlington House, the maintenance of Down House, and information services. A pamphlet explaining in detail the objects of the fund can be obtained from the secretary of the Association. It was also announced at the inaugural meeting, that the general committee had elected Sir Henry Tizard, K.C.B., F.R.S., President of the Association for the meeting to be held at Brighton next year.

Under an arrangement between the British and American Associations for the Advancement of Science, an American speaker addresses the British Association and a British speaker the American Association in alternate years. This year, Dr. Kirtley F. Mather, of Harvard, spoke on "Petroleum To-day and To-morrow" at a meeting held in the Art Galleries on Friday, August 29. On Saturday, August 30, a meeting of the Division for Social and International Relations of Science was held in the Art Galleries under the chairmanship of Dr. C. H. Desch, F.R.S. The subject for discussion was "Operational Research in War and Peace," and the opening speaker was Sir Robert Watson Watt, C.B., F.R.S. An evening discussion on "Camouflage" was delivered by Dr. Hugh B. Cott, on Monday, September 1, and on the following day there was a discussion on "Education of the Man of Science," at which Sir Henry Dale, President of the Association, was the chairman and opening speaker. In addition, several public lectures were delivered by prominent members of the Association in various towns in the neighbourhood of Dundee.

SECTION G.—ENGINEERING.

The sectional programmes commenced in the morning of Thursday, August 28, the meetings of the Engineering Section, to which we must confine our attention, being held in the Engineering Department of University College. The President of the Section was Sir William Halcrow, who occupied the chair, and the first item on the programme was the delivery of his address which was entitled "Progress in Modern Engineering." We commenced to reprint this address on page 210, *ante*, and it is concluded in this issue on page 236. After its delivery, a vote of thanks was proposed by Dr. R. V. Southwell, F.R.S., and carried by acclamation. As is the usual practice, there was no discussion on the address.

SOIL MECHANICS.

The address was followed by two short papers, the first, by Mr. N. Cochrane, giving an "Analysis of the Position in Soil Mechanics," was reprinted on page 213, *ante*. Mr. Cochrane summarised his paper and the first speaker in the discussion which followed was Dr. A. P. Thurston, who asked the author if he could throw any light on the stabilising of cliff surfaces, particularly vertical surfaces in which there were various strata. In some cases, there might be a light soil on a deep solid-clay foundation and the light soil was liable to slip on the colloidal clay. In reply, the author said the problem was mainly one of the presence of water, and stability could be obtained by keeping the water away. In other cases, the instability was purely static and nothing could be done except to cut back the face of the cliff. He referred to a case in which slipping had been prevented in a cutting by inserting an electrode in the inclined face and boring a well in the upper horizontal surface. The electrode was negative and the well was made positive, the effect being to change the hydraulic gradient so that slipping did not occur.

Wing-Comdr. Cave-Browne-Cave asked if the presence of vegetation, particularly grass, were beneficial in stabilising sloping surfaces of the kind being considered. In reply, Mr. Cochrane said he thought that while grass would be useful in protecting a sloping surface against rain, it had no effect on the overall stability conditions.

THE DEVELOPMENT OF DRY DOCKS.

After a vote of thanks to Mr. Cochrane had been carried, the chairman invited Mr. H. Ridehalgh to give his paper on "The Development of Dry Docks." This paper is reprinted on page 239 of this issue of ENGINEERING. In opening the discussion, Dr. A. P. Thurston remarked that the author had said nothing about the constructional materials for docks, or about the influence of Roman cement which had been the almost universal material of construction until after the Great Exhibition. He wished to point out that both Roman cement and Portland cement were English inventions, and asked if the author could give some information on the use of these materials. In reply, the author said he had no information on Roman cement, but Portland cement concrete had superseded granite almost entirely. He advocated the use of concrete instead of granite for the seals. Mr. W. S. Thompson referred to the use of a radial gate and asked the author if he had had any experience with gates of this type. To this question Mr. Ridehalgh replied that he had not. Sir William Halcrow then expressed agreement with the author's views regarding the need for a simpler form of joint between the caisson and the masonry. He well remembered the immense amount of labour that had to be expended in dressing granite faces and greenheart to a high degree of accuracy to ensure a satisfactory joint. It could, however, be done much more simply. In the case of some very large steel gates, not for dock work, for which he had been responsible, a specially-designed rubber seal had been most effective. There was no reason why a similar device should not be employed in the case of steel bearing against concrete because the rubber would adjust itself to any inequalities in the concrete surface, and the work, and also replacements, would be much cheaper. He proposed a vote of thanks to the authors of both papers and the meeting then adjourned. In the afternoon, the members visited the experimental jute mill of Messrs. Fairbairn, Lawson, Combe, Barbour, Limited, and the Camperdown Jute Works of Messrs. Jute Industries, Limited.

TIDAL MODEL OF THE FIRTH OF TAY.

Sir William Halcrow again occupied the chair when the meeting was resumed on the morning of Friday, August 29. The first item on the programme was a paper by Professor J. Allen, D.Sc., M.I.C.E., on the Tidal Model of the Firth of Tay, constructed by the Dundee Harbour Trust to investigate the effects of works proposed by the engineer to the Trust, Mr. N. A. Matheson, M.I.C.E., upon the general regime of the Firth of Tay. Before dealing with this model, Professor Allen spoke on hydraulic models in general and illustrated his remarks by a

large number of lantern slides. The first slide compared the results of model and full-size tests on a hydraulic turbine of some 6,000 h.p., and showed that the efficiencies obtained in the model tests were rather lower than those obtained on the full-size turbine, owing to scale effect. The next slide showed a weir for one of the Scottish hydro-electric schemes, the model having been made to ascertain the coefficient of discharge of the weir. Two models were made, one to a scale of 1 : 24 and the other to a scale of 1 : 6, and the results obtained with the two models were practically identical. A slide was then shown of a bell-mouth spillway for the Lady Bower reservoir, and Professor Allen explained that the model had been made to ascertain the effect of making the side walls of the spillway in the form of a series of steps, for reasons of economy in construction. The model had shown that the stepped form of wall had no detrimental effect on the discharge, which was, in fact, rather increased in comparison with a spillway having the side walls made in smooth curves. Some slides of a ship-model tank were next shown, and the author explained the principles involved in tank tests of ship models. The next model referred to was one made at Vicksburg to show the effects of a breakwater at Port Washington on Lake Michigan. As a result of the tests, it was recommended that wave-absorbers, consisting of piles of broken stones, should be constructed in the harbour, instead of extending the breakwater. In spite of this recommendation, the breakwater was extended, but the work did not prove very effective, as had been predicted would be the case.

For studying the heights of waves, Professor Allen said, good agreement was obtained between model and full-scale measurements if the model were made to the same scale in both the horizontal and vertical planes. For studying tidal flow in rivers and estuaries by means of models, however, it was necessary to employ a larger vertical than horizontal scale. If the same scale were employed for both, the rise due to the tides would be immeasurably small and the effects of surface tension would be serious. To illustrate the construction of models, slides showing the model of the River Severn, made by Professor Gibson, to investigate the effect of the proposed tidal barrage, were exhibited, as these showed the model in course of construction. A model of Liverpool Bay, including the estuaries of the Mersey and Dee, was referred to, its purpose being to improve the approach channels outside the Port of Liverpool. Different forms of training walls had been investigated and a number of small electric fans had been employed to simulate the effect of the prevailing winds. A solution of potash-alum had been injected into the water in the model to study the effect of the coagulation of silt in suspension by the salt water of the sea. Tide-producing mechanism for hydraulic models was next illustrated and explained, and one of the slides showed an epicyclic gear train designed to produce the effect of the lunar cycle in causing spring and neap tides. After a reference to the Rangoon tidal model, which Professor Allen said had served to show that conditions in the estuary would improve naturally, without any constructional work, he proceeded to illustrate and describe the somewhat similar, but larger, model of the Firth of Tay, constructed by the Dundee Harbour Trust. This model, which the members were able to inspect in the afternoon, is fully described in Professor Allen's paper, which is reprinted, in abridged form, on page 238.

The discussion was opened by the chairman, Sir William Halcrow, who referred to the Severn Barrage model, the work on which had been in charge of Professors Gibson and Allen. It had been started in 1926, and had occupied six or seven years. Recently the Severn Barrage scheme had been reconsidered, and a report had been prepared for the Minister of Fuel and Power in 1944. It had been decided that the design of the barrage should be altered considerably. It was now possible to get with 32 turbines the same energy as with 72 turbines formerly. In the present design there were two power stations, each containing 16 turbines. The alteration in design would require further study by a hydraulic model, and the Minister of Fuel and Power had agreed to another model being constructed. This was now being done at the National Physical Laboratory. Another matter to which he wished to refer was the setting up of a new hydraulic research laboratory in this country. In other countries, such laboratories had been in operation for many years. There were very fine hydraulic laboratories in Pittsburg, in Delft, and at Grenoble, but there were no similar facilities for experimental work in this country. He was glad to say that the Government, through the Department of Scientific and Industrial Research, had now agreed to the setting up of a hydraulic research laboratory. A new research board had been formed under the Department of Scientific and Industrial Research and Professor Allen was a member of this board, of which he had the honour to be chairman. The organisation had been started, and it was hoped that in due course this country would have a hydraulic research laboratory second to none in the world.

The only other speaker in the discussion, Mr. J. S. Wilson, said that Professor Allen's references to the model of the Dee estuary had reminded him of the investigations that had been made there several years previously. At that time the difficulty had been that there was not enough shipping to warrant the expenditure that would have been incurred in the scheme, but that suggested in the slide shown by Professor Allen appeared to show that very costly works were contemplated.

The Testing of Structural Connections.

No other member wishing to speak on Professor Allen's paper, the chairman invited Dr. A. W. Hendry to give his paper on the "Testing of Structural Connections." Dr. Hendry then read his paper, which will be reprinted in a subsequent issue of ENGINEERING, and at its conclusion the chairman invited members to ask any questions. In response to this invitation, Mr. J. S. Wilson said that a notable feature of the paper was that the results of the tests on 20 frames made by ten different firms were in such good agreement, and asked whether one sample had been taken from each of the firms or whether each had made several and the best had been selected. To this the author replied that two frames had been made by each firm and had been tested as received. He had heard no complaints regarding the difficulty of welding material ¼-in. in thickness and there had been no obvious failure in the welds.

A speaker, whose name was not announced, asked if it would not have added considerably to the strength of the joint if the outer flange had been radiused; and to this the author replied that what was done to the outer flange made very little difference. Mr. Wilson, who spoke again, asked what was the "approximate method" referred to by the author in connection with the stress calculations; and Dr. Hendry replied that he had taken the load acting through the pins and determined the bending moment and shearing force on sections normal to the axis, using the Vierendeel formula to calculate the flange stresses. Dr. W. J. Kearton referred to the use of "Catalin" in the photo-elastic tests and asked how soon the experiments had been made after machining the material. He notioed, from Fig. 7, of the paper, that there were only two fringes in the web, which was doubtless due to the thickness, but he felt that accurate stress measurements could hardly be obtained with only two fringes. In reply, Dr. Hendry said there were only two fringes in the web because its thickness was only 0·1 in. He agreed that the results were less accurate than would have been obtained in a normal photo-elastic test showing a large number of fringes. The Catalin models were cut on a vertical milling machine and were tested immediately afterwards. It took several hours to machine the models and the edges cut first would tend to round off in a manner peculiar to Catalin. It was necessary to use well-cured material and test it as soon as possible after machining. A "creep" effect was also encountered with Catalin, but this could be overcome by calibrating the model from itself—taking the stress at some point in the frame where the distribution was known. A high order of accuracy was not claimed for the photo-elastic tests, but the approximate results were useful.

After the author had replied to some further questions by members, the chairman said the time available had expired, and called on Wing-Comdr. Cave-Browne-Cave to give his paper on Roof-Top Roadways.

Roof-Top Roadways.

Wing Comdr. Cave-Browne-Cave then explained the general plan for constructing roadways at roof-top level (100 ft. above ground level) to provide additional channels for the rapid flow of traffic in city areas. He was followed by Mr. D. H. McPherson, who read another short paper dealing with the subject from a constructional point of view. Both papers will be reprinted in subsequent issues of ENGINEERING.

The discussion which followed the reading of the papers was opened by Sir William Halcrow, who recalled a scheme which had been prepared for the Royal Commission on London Traffic in 1904. In this, two overhead roads had been proposed, one of which was to have commenced at Ealing and continued to Dagenham, while the other would have started at Hendon and terminated at Coulsdon. It had not been intended that the roads should follow the main streets of London; less important parts had been selected, but Oxford Street would have been crossed by bridges, which need not have been unsightly structures. If that scheme had been carried out, even in part, the traffic difficulties of London would not have been so great as they were to-day.

Mr. D. B. McLay, M.I.C.E., said that he could not wholly support the proposed roof-top roads, though he agreed that there was a pressing need for elevated roads to cope with London traffic. As City Engineer of Dundee he would have no great objection to the scheme if it were confined to London, although he felt that the charm of some London streets lay in the broken sky-line formed by the buildings. Roof-top roads would give a uniform sky-line which would be far from attractive. Another objection to such a scheme was that it could be carried out only as a Government-aided project because of the heavy costs involved in acquiring the ground for the route. Furthermore, a standardised type of building would be necessary, and the private owner of property would not readily agree to having the design of the façade of his building regulated to give the uniform sky-line. The scheme could be carried out only if the Government acquired the ground and constructed the buildings, which could be let to tenants who wanted that class of building. He agreed that a bridge might be pleasing in design and could harmonise with its surroundings, but he felt that a long stretch of roadway at roof level would not be an added attraction to the architecture of London. In Dundee a great problem was caused by the steepness of the roads. A difficulty facing Dundee was to arrange for a traffic artery that would rise from the lower levels of the city to the higher residential districts, but he would not put forward the suggestion that there should be roof-top roads in Dundee.

In reply, Wing-Cmdr. Cave-Browne-Cave said that the assumption on which he and Mr. McPherson had worked was that something had to be done to produce traffic channels. It was not a question of whether one would like to have traffic channels or not; something had to be done to meet the definite requirement which the Commissioner of Police had stated. He claimed that the roof-top road was the right answer. Of course, such a scheme would have to be carried out by the Government, and so, for that matter, would any alternative scheme. With regard to the objections of an æsthetic nature, there were a large number of railway viaducts in London, and he had not heard complaints about their architectural appearance. Some of the architecture about which people were most enthusiastic was in Regent Street, where there was a continuous sky-line. Kingsway had a very nearly continuous line, although little gaps in it gave a certain amount of variation. With a roof-top road, the only uniformity that there need be was in the straight line at the top, and if it were thought worth while to break that up, architects could do all that was required.

The next speaker, Mr. J. S. Wilson, suggested that, if there were no noise trouble, an alternative

to having the road at a height of 100 ft. might be to construct it at a height of 20 ft., and let it run behind and through the buildings. Such a road would overcome the objection to a uniform sky-line.

To this Wing-Cmdr. Cave-Browne-Cave replied that Mr. Wilson's suggestion was unacceptable from the noise point of view. Noise would not be reflected from a roof-top road, but a road at a lower level would introduce noise trouble. Mr. John Grove asked if any difficulties were anticipated with regard to drainage, wintry-weather conditions and fog, to which the author replied that fog was a little less dense at a height of 100 ft. than at ground level. The drainage of the higher road would be the same as that of one at ground level, or possibly easier. He did not anticipate any particular difficulty in the disposal of snow.

Owing to the lateness of the hour, the chairman then adjourned the meeting until Monday morning, September 1. In the afternoon, in addition to the visit of inspection to the Firth of Tay model, previously mentioned, some of the members visited the Caledon Shipyard of the Caledon Shipbuilding and Engineering Company, Limited. On Saturday, August 30, a party of members of the Engineering Section visited the Tummel-Garry hydro-electric project which is under construction near Pitlochry. Some particulars of the scheme will be found on page 192 of our issue of September 7, 1945.

(To be continued.)

LETTERS TO THE EDITOR.

JORDAN VALLEY IRRIGATION IN TRANSJORDAN.

TO THE EDITOR OF ENGINEERING.

SIR,—Much of Mr. Sitz's letter on page 40 of your issue of July 11, 1947, is taken up with refuting things that I did not assert in the article on page 241 of your 162nd volume (1946) to which he refers. His starting point is that I ignored development schemes, and he "accepts" an "assumption" which gives him this meaning; but the assumption and the terms used to express it are his, not mine. They are not to be found in or inferred from either my lecture to the Royal Central Asian Society or my article. They are incompatible with my statement, in the lecture, that "there are many schemes of development, but . . . all these schemes, all these possibilities of development will be necessary . . . to maintain the existing population and their children. Therefore, if new immigrants are imported and put on to the land it means, inevitably, that, for every immigrant brought in and put on the land, one man of the existing population will be squeezed off it. That conclusion seems to me to be absolutely inescapable if you take Palestine according to the definition now given—that is to say, the country within the present political boundaries of Palestine."

My whole theme turned on the relation of the resources to the needs of the existing population and their children to come. Even if Mr. Sitz's estimates of development potentialities be accepted, they do not answer my point; but they are not acceptable at the face value Mr. Sitz appears to place on them. I was talking of Palestine as it is; and I know of no estimate as high as that given by Mr. Sitz for the water resources of Palestine alone. Several have been published which include water belonging to the neighbouring Arab States of Syria, Lebanon and Transjordan—but they are not Palestine. Mr. Sitz does not define fully where the water comes from. He includes "the Jordan"; but other countries have rights in these waters. He includes half the Yarmuq; but this river flows predominantly in Syria and Transjordan. There might be all sorts of possibilities of international agreements, but the emphasis Mr. Sitz gives to this point only lends added weight to my thesis that Palestine's *own* resources are inadequate. Otherwise, why go outside Palestine, to make up the estimates? Traditionally, the Zionist case has been grounded economically on the notion that Palestine is a country aching for the settler's plough. Nothing could be more convincing as proof of the falsity of this claim than the fact that Zionist planners have been obliged to boost up their estimates by relying on the diversion to Palestine of waters belonging to neighbouring Arab States, whose opposition to the purpose for which those waters are required has strengthened in proportion as the need for them has been created by immigration. To recognise the facts is a clear duty, wherever one's political sympathies may lie. I was not "arguing" that to divert water from one country to another requires the consent of the former; I was stating it as a fact.

Mr. Sitz makes a comparison of water duties and finds that 700 cub. m. is less than 1,690; so it is, but, while superficial arithmetical comparison of water duties may make a rhetorical point it has no value in technical discussion. I should have been able to discuss what comparison could legitimately be made if Mr. Sitz had given some data to show what his 700 cub. m. really means and how it is made up.

He next chooses to imply that it is my opinion that there has been a basic change in the climate. What I said could more justifiably be interpreted in the opposite sense. I said that an exact correspondence between the rainfall and the water supply, past and present, is not tenable, which is a very different thing. In fact, as I pointed out to the Royal Central Asian Society, every year there is a different rainfall. The average every five years is different; it varies from year to year, and from period to period. There are records of rainfall in Palestine running back into middle of the past century, and there are periods when the rainfall has been 10 to 15 per cent. different from the general average. Nevertheless, Mr. Sitz finds that the main conclusion I drew fits his own forecast, namely, of a declining agricultural percentage. There can be no doubt whatever that to provide more agricultural land in Palestine is a major economic necessity, and that sufficient does not exist in Palestine alone. Hence, the agricultural percentage is bound to fall.

While agreeing with me as regards the trend, however, Mr. Sitz does not accept that it is a necessity. He says: ". . . It is clearly realised that a well-established urban population is a prerequisite for the development of local agriculture and that the agricultural population should never be more than a certain percentage of the total population." For a generation, Zionism has sought to convince the world that Palestine's economic boot can be lifted by hoisting on its agricultural bootlace. Mr. Sitz tells us that economists in Palestine now think that the industrial bootlace must do the trick, lifting the agricultural boot with it. That a *volte-face* of this character can happen is probably due to the fact that the real hoisting power in the Jewish economy is external, not internal; it is a subsidised economy. As a matter of fact, I did not discuss the country's economy as a whole either in my lecture or the article. What I said, in effect (in my lecture), was that agriculture as an economic justification for immigration is not tenable, and this seems to be inseparable from what Mr. Sitz himself says.

Claims are still heard that the Negeb could be developed for irrigation on a major scale by exploiting wells. Extensive tests have been made and the prospects are poor. The mere existence of a test well, even if the water is sweet, is not sufficient evidence for supposing that hundreds of additional wells can be successfully developed; it is the rate of inflow into the ground-water reservoir that matters, and the existence of a water table is only part of the evidence. In illustration of this, I instanced, in my lecture, what has happened in the coastal plain where, in fact, there has been some over-pumping. Mr. Sitz removes my words from their context, and takes the opportunity to claim that the Water Research Bureau of the Jewish National Institution consider that "the present consumption of underground water is no more than one-fifth of what may safely be withdrawn." I feel no doubt that, if space had permitted Mr. Sitz to give the supporting calculations, he would have disclosed many doubtful assumptions and limiting qualifications, without which his words appear to say a great deal more than they can possibly mean. As regards surface run-off, the important thing is, how much of the aggregate can be made use of in practice. Mr. Sitz does not say; all I can reply is that I find no fault in his arithmetic as far as it goes.

I am in full agreement with Mr. Sitz that the development of the Jordan and Yarmuq can serve as a point of co-operation and mutual assistance. At present, Transjordan is debarred from taking any of these waters by the Rutenberg Electricity Concession, as I explained in my article in ENGINEERING, on which Mr. Sitz's letter is a commentary. The first and most desirable act of mutual assistance is that the Concessionary Company and the Government of Transjordan should co-operate in agreeing to free that share of Transjordan's waters which should be available to Transjordan. Mr. Sitz says that I had only one year's gaugings. The only important sources of irrigation water in Transjordan are the Jordan and the Yarmuq, for which I had 17 years' and 13 years' gaugings, respectively, as he must have been aware. He says that the water resources are greater than my estimates, but does not say what he thinks the figures ought to be, or how much the estimates should be increased. I can only comment that, to the extent that supportable data may prove what he says to be correct, he is, no doubt, correct; but, I repeat, it is the amount that matters, and on this he says nothing. If he has new facts, why did he not give them, with their supporting authority?

Mr. Sitz goes on to say that I "disregarded a number of points which have been taken into account by the American engineers," and instances storage of the Yarmuq waters, for which the American engineers have provided. He seems to have assumed that the project I outlined is comparable, as a project, with the Hays-Savage projects. How could it be? One relates to Transjordan, the others to Palestine. Naturally, there are many alternative methods, and many ways in which joint works could serve the two countries. If my article has stimulated constructive thought as to how the water rights of countries other than Palestine can be covered when major projects are planned, it has served its purpose.

My comparisons of cost were on capital costs, not on unit costs of water delivered. I should not have ventured to compare the unit cost per cubic metre delivered without having made very sure that the basis of calculation—the rate of interest, maintenance charges, etc.—allowed a valid comparison to be made at all. Mr. Sitz does not say whether or not he has satisfied himself on this. To transfer the basis of comparison a step farther, as Mr. Sitz does, to consideration of the economic value of the products of agriculture, introduces another set of highly debatable factors, of which the most important, perhaps, is the subsidised nature of the Jewish agricultural economy. A true comparison must also take into account, *inter alia*, the fact that, in some places, irrigation water is additional to the direct rainfall: how much of the total productivity is to be ascribed to the additional irrigation water? It is not profitable to make debating points on superficial arithmetic manipulations.

There is no room for dispute that the "big" schemes in the Jordan Valley are enormously expensive, as Middle Eastern costs go. This is not the "fault" of the engineers who design them, and Mr. Sitz misses the point by representing the issue as one of a conflict of personal engineering opinion. The scheme I outlined for Transjordan is also enormously expensive by Middle East standards, though it is only a quarter that of the Hays-Savage scheme in terms of capital cost per unit of water capacity. If I were to attempt to outline a scheme to use a greater percentage still of the total available water, it would be more expensive still per unit. I have no doubt that, if I were to attempt a scheme to make use of something approaching the total average annual water supply from all sources, with all the capital works which would be necessary, the cost would be fully comparable with that of the Hays-Savage scheme. The unit cost rises steeply as the ultimate limit of development is approached. The engineer can't help it. But the fact that these exhaustive projects, with their necessarily high costs, can be contemplated, whether in the Hays-

Savage scheme or the lesser and therefore cheaper-per-unit scheme which I outlined for Transjordan, is very significant indeed.

I can best repeat what I have said elsewhere* since the lecture and article were written: "Naturally people are puzzled; they hear that there are many different kinds of possibilities of water development in Palestine—and so there are: wells, dams, storm-water run-off, improved canal systems and so on—and they wonder how it can be said that there is not much scope for further development of the country in the sense of making new land available. . . . The mere fact that all these possibilities of development are being canvassed and are the subject of serious inquiry is in itself the most convincing evidence that development (potentiality) has reached its limit and that the country is agriculturally saturated. Even such a scheme as Hays' would not provide the land necessary even for the natural increase in the existing agricultural population. No one would dream of spending such vast sums as the Hays scheme involves for such a modest increase in irrigation water unless it was the very last resort to escape the penalties of an immigration policy which, as experts have consistently advised, the country's agricultural resources cannot sustain."*

Yours faithfully,
M. G. IONIDES.

4a, Launceston-place,
London, W.8.
August 19, 1947.

THE NORWICH HEAT PUMP.

TO THE EDITOR OF ENGINEERING.

SIR,—I have to thank your correspondent "Historicus" for his letter, published on page 160 of your issue of August 15, dealing with Messrs. Coleman and Bell, as certain of the historical facts which he has given were not known to me, and may be new to many of your readers.

I was particularly anxious, in my paper, to refer to the fact that a practicable cycle of operations for the reversed heat engine was actually adopted by Coleman, as this fact is not always clearly established, and it seemed desirous to establish this particular historical point. While I do not wish in any way to dispute the facts given by "Historicus," I would point out that my tutor in thermodynamics (the late Professor W. Robinson, of Nottingham University College), who, I believe, was closely associated with Bell and Coleman, always referred to the "Bell-Coleman" machine; as did one of his pupils, the late Mr. W. Inchley, in his standard work, *The Theory of Heat Engines*. It would seem, however, that my paper and this correspondence have resulted in proper tribute being paid to Coleman's original work.

Yours faithfully,
JOHN A. SUMNER,
City Electrical Engineer.

Electricity Department,
Duke-street, Norwich.
August 27, 1947.

AIR-SPEED RECORD.—On page 212, *ante*, we reported that the air-speed record had been raised to 640·7 miles an hour by a Douglas Skystreak aircraft. This record has since been raised to 650·6 miles an hour by a similar machine, but piloted by Major Marion Carl of the United States Marines. It is understood that in both cases the aircraft were not modified and that no special fuels were used to increase the thrust of the power units. The Skystreak is an experimental aircraft and two such machines have been delivered to the United States Navy for high-speed research. As pointed out in our previous report, the aircraft is of conventional construction, being a single jet machine in which the power unit is installed in the centre of the fuselage, the air intakes and jet nozzle being located in the nose and tail of the machine, respectively. It has been learnt since, however, that it has a span of 25 ft. and a length of approximately 35 ft., while the power unit is a General Electric TG-180 axial-flow turbo-jet having a maximum rating of 4,000 lb. thrust.

* *The Geographical Journal*, vol. 108, page 175 (1946).

BABBITT ALLOYS FOR PLAIN BEARINGS.

By P. G. FORRESTER, M.Sc.

(*Concluded from page* 209.)

SEVERAL different methods are used for the manufacture of Babbitt bearings. In this article, principal attention is given to methods of general application rather than those suitable only for mass production. In all methods, two principal aims must be served: firstly, a strong and continuous bond must be obtained between lining and backing material; secondly, the optimum physical properties must be obtained in the Babbitt itself. The means by which these aims may be achieved are basically the same in all methods of manufacture.

While it is possible, under ideal conditions, to obtain a fairly good bond by lining Babbitt directly on to the clean basis material, such a method is not commercially practicable; in any case, the basis material must be preheated before lining and it is difficult to prevent contamination during preheating. Consequently, pre-tinning is always used in practice. The tinning process automatically preheats the basis material, and, by proper choice of conditions, enables the metallurgical character of the bond to be controlled. The preparation of the basis material thus consists of two stages—cleaning and tinning. The first step in the cleaning process consists of machining or shot-blasting; this is followed by a degreasing treatment, to remove grease films which would interfere with the subsequent chemical treatment. The next step is usually pickling in some acid solution, though for cast iron and some alloy steels treatment in fused salts is preferable.* The metal surface should then be chemically clean, apart from a very slight oxide film which forms immediately the metal is removed from the pickling solution. This oxide film is removed by means of an active flux, applied to the surface of the metal before immersion in the tin bath.

Different basis materials require different cleaning and tinning treatments. Suitable methods for the common materials are shown in the suggested procedure on this page. It is not suggested that these are the only suitable methods, but all those given have been found to give satisfactory results in practice. Aluminium and its alloys are not included, as they require entirely different treatment. No fully satisfactory chemical cleaning process has yet been devised for aluminium, but good tinning can be obtained by scratch-brushing while immersed in molten tin. Tests have shown that the bond strength obtainable on aluminium alloys tinned by this method is of the same order as on steel tinned by the usual process.

Assuming that the backing material has been properly tinned, good adhesion between backing and lining depends primarily upon three factors. First, the tin layer on the backing must be completely molten when the Babbitt is poured on to it, so that the oxide skin on the surface of the tin is floated off by the Babbitt. Secondly, the solidification of the Babbitt must take place from the bond inwards. As Pell-Walpole† has shown, the importance of directional cooling is in preventing the formation of contraction cavities at the bond. All Babbitts solidify over a range of temperature, and it is while the metal is in the pasty range that contraction cavities tend to form. If an adequate supply of liquid metal is available for feeding, these voids are filled as they form, but if no liquid metal is available, cavities remain in the solidified Babbitt. Consequently, in any Babbitt casting, contraction cavities will be found in the last part of the metal to solidify. If the last part to solidify is at the surface away from the bond, the porous metal is removed when the bearing is machined, but, if the metal at the bond is the last to solidify, cavities occur there and result in a low bond strength.

The third main factor in determining bond strength is the rate of cooling. The optimum rate depends on the composition of the Babbitt and the size of the shell to be lined. The rate of cooling may be controlled by variation of the metal temperature and cooling method, and both these factors influence the bond strength, as is shown by the bond-strength figures given in Table II. These figures were

SUGGESTED TINNING PROCEDURE.

(1) *Mechanical Cleaning.*

Machining (fine finishing cut preferred); or shot-blasting; or sand-blasting.

(2) *Degreasing.*

Solvent degreasing (*e.g.*, in trichlorethylene vapour); or degreasing in alkaline cleaner (preferably cathodically); or stoving.

(3) *Chemical Cleaning.*

Steel:—10 per cent.† sulphuric acid + 0·05 per cent. inhibitor at 80 deg. to 90 deg. C., for 2 to 10 minutes; or 50 to 75 per cent. hydrochloric acid, cold, for 5 to 30 minutes.

Bronze:—15 per cent. nitric acid, cold, for 5 to 20 minutes; or 10 per cent.† sulphuric acid + 2 per cent. nitric acid at 75 to 80 deg. C. for 2 to 16 minutes.

Cast Iron:—anodic etch in sulphuric acid, then electrodeposit 0·001 in. of iron; or fused chloride bath treatment*; or pickle in 10 per cent† sulphuric acid followed by fused nitrate bath treatment.*

Alloy Steel:—25 to 60 per cent. nitric acid; or anodic etching in 60 per cent.† sulphuric acid; or fused salt bath treatment as used for cast iron.

(4) *Fluxing.*

(i) Zinc chloride; or
(ii) 90 per cent. zinc chloride + 10 per cent. ammonium chloride; or
(iii) 82 per cent. zinc chloride + 18 per cent. sodium chloride.

} In 25 to 40 per cent. aqueous solution.

(5) *Tinning.*

Pure tin for tin-base Alloys
50 : 50 tin-lead for lead-base and intermediate alloys

} Steel, 300 deg. to 350 deg. C.
Bronze, 260 deg. to 280 deg. C.
Cast iron, 300 deg. to 350 deg. C.

* To be preferred. † By weight.

TABLE II.—*Bond Strength Values for Various Alloys and Conditions of Lining.*

Composition of Babbitt.	Pouring Temperature (Deg. C. Above Liquidus).	Cooling Method.	Bond Strength (Tons per sq. in.).
7 per cent. Sb, 3½ per cent. Cu, rest tin	50	Rapid water cool	5·47
	50	Slow water cool	4·82
	50	Air cool	4·55
	100	Rapid water cool	4·51
7 per cent. Sb, 7 per cent. Cu, rest tin	50	Rapid water cool	2·67
	50	Air cool	2·05
	100	Rapid water cool	2·15
9 per cent. Sb, 2 per cent. Cu, 1 per cent. Cd, rest tin	5	Rapid water cool	4·84
	50	Rapid water cool	2·43
	50	Slow water cool	4·37
	50	Air cool	6·21

obtained by Forrester and Greenfield,* using a vertical lining jig. Bond strengths were measured by the method described by Chalmers.† This consists of isolating a plug of white metal by means of a trepanning drill, then drilling a co-axial hole through the steel by a flat-ended drill. By forcing the plug of white metal off the steel by means of a ram in a compression jig, the bond is fractured over an area of annular shape.

It will be seen that, with the tin-antimony-copper alloys without cadmium, factors which increase the rate of cooling increase the bond strength. Rapid cooling is particularly necessary for the alloy containing 7 per cent. of copper. The low bond-strengths observed with this alloy with the lower rates of cooling were found to be due to a layer of intermetallic compound Cu_3Sn_5, at the bond, the formation of which was largely prevented by using a low metal temperature and rapid water quenching. For the alloys containing cadmium, on the other hand, the best bond strength is obtained with slow cooling. This has been observed previously by Pell-Walpole,‡ who suggests that the high creep strength of the cadmium-containing

* R. A. Cresswell, *Jl. Iron and Steel Inst.*, vol. 152, page 157 (1945).

† W. T. Pell-Walpole, *Jl. Inst. Met.*, vol. 68, page 217 (1942).

* P. G. Forrester and L. T. Greenfield, *Jl. Inst. Met.*, vol. 73, page 55 (1946).

† B. Chalmers, *Jl. Inst. Met.*, vol. 68, page 253 (1942).

‡ *Loc. cit.*

alloys prevents them from yielding readily to the stresses produced by differential contraction of backing and lining, and results in the formation of cracks at the bond.

These results were obtained with small specimens. It is likely that, in large bearing shells, high rates of cooling would cause cracking even in cadmium-free alloys. For large shells, cooling by air-blast or fine water spray is thus preferable to water quenching. Moderate rates of cooling are also to be preferred for brittle alloys such as the low-tin lead-base alloys. The cooling methods most suitable in particular circumstances may be summarised thus:

Small Shells.

Tin-base, intermediate or lead-base with more than 10 per cent. tin: use water immersion or spray.

Tin-base containing cadmium or lead-base with little tin: use air-blast.

Large Shells.

Cadmium-free tin-base or intermediate: use water spray or air blast.

Other alloys: use air-blast.

A low casting temperature favours good adhesion, but other considerations enter into the choice of casting temperature. If it is too low, the metal will not flow readily enough to fill the jig. The most suitable casting temperature depends largely on the composition of the Babbitt, though the lining method and size of bearing may have to be taken into account. For hand lining with tin-base Babbitt, a temperature of 50 deg. C. above the liquidus is satisfactory for alloys containing 4 per cent. or less of copper. With more than about 4 per cent. of copper, temperatures only a little above the liquidus are to be preferred, for better bond strengths are obtained with lower temperatures. On this basis, the temperatures given in Table III are suggested. The metal should never be heated above its casting temperature. Overheating results in excessive oxidation and may result in the contamination of the metal with abrasive SnO_2 particles.

TABLE III.—*Casting Temperatures of Tin-Base Alloys.*

Antimony.	2 Per Cent. Cu.	4 per Cent. Cu.	6 Per Cent. Cu.	8 Per Cent. Cu.
	Deg. C.	Deg. C.	Deg. C.	Deg. C.
4 per cent.	340	400	410	420
8 ,, ...	330	380	390	410
12 ,, ...	320	380	390	410

The hand-lining of bearing shells is carried out in various types of jig, of which the vertical jig, shown in Fig. 3, is generally the most satisfactory. The shell, heated by immersion in the tin pot and covered with a suitable flux, is clamped against a back plate round a mandrel. Both back plate and mandrel should be heated previously to a temperature above the melting point of the metal (they may also be heated in the tin pot). The metal is stirred and skimmed, and then poured into the space between the shell and mandrel. The metal should be poured down the surface of the mandrel (not down the shell) and splashing should be avoided as far as possible. The major advantage of this type of jig is that proper control of cooling can be readily obtained. If the shell is cooled by water or air-blast, solidification begins at the bottom of the shell and at the bond, so that the liquid/solid interface moves up the shell. Thus there is always a head of metal to feed the bond, preventing the formation of contraction cavities. The metal at the top may be kept molten by means of a blowpipe and fresh metal added as the level falls through contraction. With this type of jig the metal is usually puddled with a steel wire as it cools, to aid the escape of entrapped air; this is especially necessary when the shell has any re-entrant cavities.

For shells with a high ratio of length to diameter, good results can be obtained with a horizontal type of jig, shown in section in Fig. 4. The metal is poured through a hole in the mandrel, and other holes set at intervals as risers. This type of jig also allows cooling from the bond inwards by air-blast or water spray underneath the shell, but puddling is difficult, if not impossible. The adhesion obtained may thus be rather inferior to that obtained with the vertical jig. A second type of horizontal jig is shown in Fig. 5. The metal is poured through a hole in the shell, and other holes in the shell act as risers. These holes are left full of white metal after lining. This type of jig gives inferior adhesion to that obtained with the jigs previously described, as dross and entrapped air tend to rise to the bond and collect there. Further, if a relatively cold mandrel is used, as is usually the case, cooling takes place from the mandrel, so that the bond is further impaired by contraction cavities. The sole advantage of this method of lining is that a good surface is obtained on the bearing metal and, for some applications, no machining is required. The method is, therefore, used in some cases where loading is not excessive and inferior adhesion can be tolerated.

Very good bearings can be produced by centrifugal casting. This method is employed for large-scale production, using special apparatus, but satisfactory results can be obtained with an ordinary lathe and a simple jig. In centrifugal lining, two tinned and heated half-shells are clamped together into a

Fig. 3.

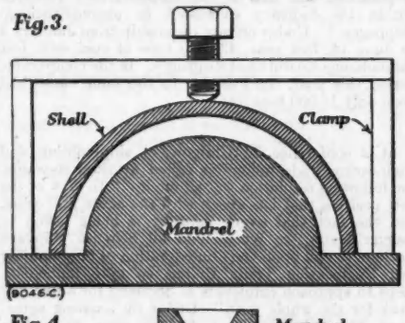


Fig. 4.

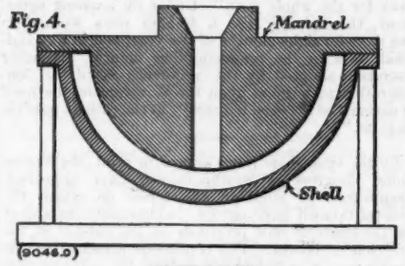
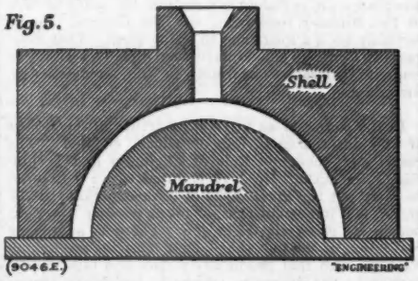


Fig. 5.



jig and spun at a speed equivalent to 800 to 1,200 ft. per minute. A measured quantity of white metal is poured in and spinning continued for a short time; cooling may be accelerated by a water spray on the back of the shells. After removing from the jig, the two half-shells are parted. When two half-shells are lined together, separating shims must be used in the bearing assembly and if this is regarded as undesirable, the two halves are spun separately, using an untinned dummy half-shell. Centrifugal casting tends to give sounder metal than static casting, for blowholes are practically eliminated and dross collects at the inner surface, which is machined off. Probably for these reasons, centrifugal casting is said to give better adhesion. Spinning results in considerable segregation in most bearing alloys. In tin-base alloys, the Cu_6Sn_5 tends to collect in the part nearest the bond, so that, if the original metal contains 3 per cent. of copper, the part near the bond, after spinning, may contain as much as 7 per cent. The inner layers of white metal are normally machined off, so that, in the finished bearing, the white metal has an average copper content much higher than that of the original white metal. In lead-base alloys the hard phases (antimony-rich solid solution or CbSn) move towards the bearing surface. Careful control is therefore necessary to avoid denuding the white metal completely of the hard phases.

Large numbers of Babbitt bearings are made by pressure die-casting. Very small lightly loaded bearings may consist entirely of die-cast white metal or of die-cast Babbitt liners inserted in a shell without bonding. Normally, however, die-cast Babbitt bearings are made by casting the white metal into a die of which a tinned and heated shell forms a part. Die-casting yields a homogeneous fine-grained metal and the inherent accuracy of the process greatly reduces the amount of machining necessary. The adhesion obtained in die-casting, however, is generally inferior to that obtained in static hand lining or centrifugal casting.

Many automobile bearings are now made with "precision" inserts of Babbitt-lined strip. In the manufacture of these bearings* flat steel strip is tinned, and then passed horizontally through a furnace to melt the tinned layer. White metal is then flowed on to the surface to a controlled depth. The strip then passes over a series of water jets, which cause the white metal to solidify from the bond upwards, and the lined strip passes to millers, which remove the excess Babbitt. Finally, it is coiled. The continuous coils of lined strip are cut into rectangles of the required size, which are formed into half-shells in a press and machined by precision methods. When strip lining is used, the white metal must be chosen not only for its bearing properties but also for its suitability for the strip-lining process; it must, for example, be able to withstand the deformation imposed in the forming operation. The machining processes to which a bearing shell is subjected depend largely on the particular application. The only general rule is that the actual bearing surface should have a fine finish produced by as clean a cut as possible. The finish, of course, will be greatly modified during running-in, but, if it is initially too coarse, running-in will bring about a large increase in clearance. For this reason diamond finishing is recommended.†

The author has utilised in this article the results of many experiments conducted by him and his colleagues at the Tin Research Institute, and is grateful for the permission accorded to him by the Institute to publish it.

UNITED STATES COAL EXPORTS.—During the year ending June 30, 1947, exports of coal from the United States totalled 29,837,000 tons, which figure constitutes a new high record.

NEW RECORDS ESTABLISHED DURING LYMPNE AIR RACES.—Two international records were established during the air races organised by the Cinque Ports Flying Club and held at Lympne on Sunday, August 31. Group Captain John Cunningham, flying a de Havilland Vampire jet-propelled fighter, set up an international closed-circuit record for aircraft of any power by averaging 496·88 miles an hour over 100 km. Previously, the record was held by a Lockheed Shooting Star aircraft which had averaged 493·88 miles an hour. Squadron Leader R. L. Porteous broke the international 100 km. record for aircraft powered by an engine of under 2 litres capacity by averaging 123·7 miles an hour over a closed circuit in a Chilton aircraft, thus beating the record of 115 miles an hour established by Germany in 1939.

THE STORY OF THE GRID.—The Central Electricity Board have seized the psychological moment to issue a well-illustrated brochure dealing with the grid and its place in the development of the electricity supply industry. As is well known, the days of the Board in its present form are numbered, which is one reason for the preparation of a history. In addition, public interest in electrical matters has undoubtedly increased, as the result of load shedding, and the greater developments in all fields, as is shown by the fact that information is constantly being sought from schools, colleges and other educational institutions. The brochure is not for sale, but copies may be obtained by those interested from the Public Relations Officer (Mr. W. J. Hendry), Trafalgar Buildings, 1, Charing Cross, London, S.W.1.

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* V. Fisher, *Metal Progress*, vol. 33, pages 587-595 (1938).

† M. Melhuish, *loc. cit.*

LABOUR NOTES.

A SURVEY has recently been completed by the Ministry of Labour and National Service to discover how Polish volunteers, recruited for coal-mining, are settling down in certain Welsh colliery districts. Results of the survey, which covered pits at Pontypridd, Llanwit Fardre, Merthyr, Resolven, and Ogmore Vale, are, it is officially stated, very encouraging. Not only are the newcomers working well, but they are on excellent terms with the Welsh mining communities. A number of the Poles have had previous mining experience in their own country and in Belgium, France, and Germany. Others are newcomers to the craft, and have received preliminary training at the Government Training Centre at Oakdale, Mon.

The type of work done by the Poles varies from pit to pit. In some, they are acting as colliers' assistants, in others, they carry out repairs, road maintenance, hard heading, driving gub heading, and packing at the coal face. Many of the newcomers are used to more easily-worked pits, but that does not affect their keenness or their energy. The men with previous experience are found to be easily adaptable to difficult conditions of work and, wherever possible, are given every chance of doing piecework, particularly on hard heading where their output is "very good indeed" in spite of a number of hold-backs.

The general view of colliery officials in these Glamorgan mines is that the Polish volunteers "are full of grand spirit." "Often," it is recorded, "they have to work under very difficult physical conditions, but they show extremely good discipline and an understanding both of local difficulties and of the present economic struggle in Britain." "Welsh miners," it is added, "are not alone in their friendly acceptance of Polish entrants to their craft. Surveys, now in progress in other parts of the country, indicate that Polish volunteers are being absorbed equally successfully elsewhere, notably in the coalfields of Yorkshire and in some parts of Scotland."

According to the Ministry's "Information Service" from which the foregoing statements are taken, the Italians who have been recruited for work in British iron foundries are doing equally well. A total of 257, it is recorded, have so far arrived in this country and have been allocated to 12 firms in the South Western, Midland, North Midland, Northern, and Southern regions and Wales. Reports, so far received by the Ministry of Labour and National Service, indicate that the men are settling in well and that employers speak favourably of the efficiency of their work. They are also reported to be on very good terms with their British colleagues. They are employed under full trade-union conditions and rates of pay, and are required to become members of the appropriate British trade union.

The National Coal Board states that the gross cost of the five-day week is "substantially more" than the 2*s.* 6*d.* per ton allowed for." This is, it is explained, because part of the gross cost has already been offset by increased ouput per manshift, and the cost will be reduced "if and when remaining restrictions on output are eliminated, and as, and when, new personnel recently recruited for the mines become fully productive."

Representatives of all the collieries in Scotland decided at a conference in Edinburgh last week to give full support to the proposal of the National Union of Mineworkers that there should be a return to the six-day week until the end of May next year. It was also agreed that Poles and other European volunteer workers should be admitted to the industry, that a general view of task allocations should be made in all Scottish pits, and that disciplinary action should be taken against deliberate absenteeism.

At a meeting in Newcastle-on-Tyne last week, delegates of the miners' lodges in the Northumberland coalfield adopted a resolution "deploring the actions of a minority in continuing those practices which are contrary to the spirit of the five-day week agreement." The employment of European workers in the mines was approved.

The trouble in the South Yorkshire coalfield over the proposal that the stint should be lengthened in order to increase output naturally gave the leaders of the Mineworkers' Union much concern, as both the original stoppage and the sympathetic strikes that followed were clear breaches of agreement to which Mr. Lawther and his associates on the executive committee are parties. Mr. Lawther did not mince matters in condemning the action of the strikers, and Mr. Arthur Horner, the general secretary, was equally outspoken on the subject. But neither was exclusively concerned about the Yorkshire trouble; the increase of unofficial stoppages and the persistance at a high level of absenteeism endangered, they realised, not only the five-day week, but also the efficiency, if not the actual existence, of the Coal Board.

Mr. Horner made that clear enough in the course of a statement issued by him last week; It was not merely, he said, a matter of 200,000 tons of coal a week; "the financial loss involved interfered with the possibility of the Coal Board meeting the requirements put forward by the union." "There must be," he declared, "better co-operation between ourselves and the Coal Board, for we sink or swim together. If the Coal Board falls, we cannot succeed in realising our objectives."

The main explanation of the Coal Board's financial losses, Mr. Horner reckoned, was low output per manshift. There were, in his opinion, technical reasons for that, but, he pointed out, the position "is made worse by something which is curable, and for which we are responsible, and that is the unsatisfactory relations within the industry expressed in unconstitutional stoppages." Under private ownership from January 4 to June 14, last year, 430,490 tons of coal were lost through unconstitutional stoppages. In the comparable period this year, the loss due to the same cause had been only 15,000 tons less.

At a conference, in Glasgow, of shipbuilding and engineering trade unionsists called by shop stewards, the following resolution was adopted: "In view of the new position that has arisen with the acute fuel crisis, and the fact that every industry is being asked to stagger hours, we recommend all Scottish shipyard workers to call upon the Confederation of Shipbuilding and Engineering Trade Unions to take immediate steps to approach employers in Scotland for a five-day week for the whole year." Under the existing agreement, the industry has a 44-hour week worked in five days for eight months of the year, and in five-and-a-half days for the remaining four months. Another resolution adopted by the conference asked the Confederation to impress upon the Government the need to nationalise the steel industry "at the earliest possible moment."

By the time these notes appear in print, the Trades Union Congress at Southport will have approved, disapproved or modified the terms on which the General Council have agreed, conditionally, to accept the Government new proposals on the subject of the direction of labour. The conditions attached to the acceptance are certainly severe from the point of view of the Minister concerned, and the General Council certainly took a long time to frame them. That delegates to Congress should have been equally hesitant to commit themselves was not, in the circumstances, surprising.

In the course of an interesting article in the *Review* of the International Labour Office, entitled "The Social and Economic Role of Engineers and Technicians," the author, Mr. J. H. E. Fried, says: "In order to carry out the great tasks of reconstruction that lie ahead, it is important that, as far as possible, the right person be given the right job. There is a growing realisation of the fact that labour relations are human relations, and that productivity rises and falls in proportion to the degree to which the legitimate aspirations of the employee are respected. In this connection, it must again be pointed out that often engineers and technicians are also personally affected by problems of scientific management and job analysis."

"Scientific management and job analysis are not," the author continues, "limited to manual jobs, and since large numbers of engineers and technicians are assigned to specialised duties according to widely ramified schemes of division of labour, their own work, their personal and professional satisfaction, their promotion and remuneration are directly influenced by the methods by which their own duties are organised and, assigned."

"In various countries," he says, "notably Belgium France, Great Britain, the United States of America and the Soviet Union, questions of scientific management have received much attention, but so far there has been little international co-ordination of these efforts. Also, within the various countries, the development has been uneven, some industries having been studied more closely than others. Compelling economic and technical conditions make the further development of scientific management a necessity. Indications are that in this field there is wide scope for engineers."

PROGRESS IN MODERN ENGINEERING.*

By SIR WILLIAM HALCROW.

(*Concluded from page* 211.)

IT is hardly necessary to draw attention to the great and ever-increasing usefulness of the light alloys based on magnesium, and especially on aluminium. The use of aluminium and its alloys for aircraft production during the war has enabled most of the metallurgical problems to be solved, and we now see them used with success in products ranging from suitcases, kitchen utensils and vehicle bodies, to transmission lines. The production of aluminium depends entirely on the availability of large amounts of cheap electricity, which can be supplied only by hydro-electric plants.

Since antiquity, man has required some bonding material in his structures, and it is known that the Egyptians employed a good lime mortar in the pyramid of Cheops. The Greeks and the Romans had this knowledge, and the Romans developed a waterproof cement or lime which would set under water, for use in their tanks and aqueducts, by the addition of pozzuolana to lime. In passing, it may be noted that the famous Roman aqueducts, which were carried straight across valleys, were probably the result of their lack of knowledge of the siphon principle. It has been said that the writings of Vitruvius were at least as valuable a guide as those of anyone else up to the early part of the Nineteenth Century, when M. Vicat succeeded in producing hydraulic limes by grinding calcined mixtures of common limes and various clays. There were, of course, various hydraulic limes being produced at this time, and by 1824, Aspdin was producing what he called "Portland" cement. Frost, at Swanscombe, was producing "British" cement, but they were both what we should class as an improved and ground hydraulic lime. Little advance was made until about 1845, when Johnson, at the Swanscombe Works, burned the raw materials to near vitrification instead of calcining them, and ground the resulting clinker into the first real hydraulic cement. Development proceeded slowly, but, by 1865, the new cement could show better strength characteristics than the hydraulic limes and towards the end of the century lime was ousted from large-scale construction.

The past hundred years have seen the slow but continuous development of the material by careful selection and handling of the raw materials, and the ultimate strength of a practical concrete is about 6,000 lb. per square inch to-day, as against 1,730 lb. per square inch in 1852. The chemistry of the processes involved is not fully understood even now, but during the past 40 years an ever-widening range of consistent and high-grade cements have been available for constructional purposes. The latest addition to the range is a low-heat cement for use in large masses of concrete-like dams and dock walls. When setting, ordinary cement emits considerable quantities of heat for several years after casting, and this causes eventual shrinkage and important secondary stresses. Some dams have cooling pipes in the concrete to reduce these effects.

Plain concrete has a relatively low tensile strength and, about the beginning of this century, a composite material of steel and concrete was evolved. The steel was placed to take up bending and bonding tensions and the design, procedure and technique was soon worked out. So successful has this reinforced concrete become that it can be used with equal facility to steel for many load-bearing structures. Ordinary reinforced concrete uses only enough steel to take up the tensile stresses induced by applied loads, and there is an inherent extravagance in that the concrete below the neutral axis of bending is theoretically unstressed and only used for holding the reinforcement in position. In the past 20 years, another type of reinforced concrete has been evolved to overcome this. Instead of the steel and concrete being initially unstressed, a high tension is induced in the steel during construction and the surrounding concrete is placed in compression. The superimposed loads then act on this initial stress system, which can be arranged so that the final conditions of stress make use of all the concrete. This pre-stressed reinforced concrete results in large economies in the mass of material used, but there are several drawbacks at present. Very high-grade concretes and steels are required, involving a much greater degree of control during construction; and the pre-stressing of the high-tensile reinforcement is not simple under practical conditions.

Earthworks are probably the oldest branch of engineering, but it can hardly be said to have changed from an art to a science until recent times. With the establishment of the Industrial Revolution, involving the construction of canals, railways, roads, dams, etc., the necessity for a fuller understanding of the qualities of the soft materials of the earth's crust became more

* Presidential address to Section G of the British Association, delivered at Dundee on Thursday, August 28, 1947. Abridged.

urgent; rule-of-thumb methods of design were no longer sufficient. The earlier half of the Nineteenth Century was, however, the great period of refinement by experience. By 1857, Rankine had produced his paper on the stability of loose earth, and the design of retaining walls and foundations became possible under certain conditions. Unfortunately, the formulæ and methods tended to be misapplied to all sorts of earth conditions, including clays, and the resulting failures did not establish confidence in analytical methods.

In the early part of the present century, several important investigations of landslides and soil problems were under way, and in 1915 A. L. Bell read his paper to the Institution of Civil Engineers on the lateral pressure and resistance of clay. This was a mathematical approach and did not treat in detail the structure of cohesive materials. In the early 1920's, however, the science of soil mechanics can be said to have started its rapid development stage, when Dr. Karl Terzaghi began to publish his detailed and penetrating analyses of cohesive and other soft materials. It was shown that the factors involved in clay were those of colloidal and near-colloidal particles, of electrostatic bonds between particles, and of forces due to capillary water as well as the normal gravitational forces. Terzaghi's work was so detailed that, by the middle 1930's, the science was already an accepted basis of design and most major Governments had established specialised research departments. The position to-day is that, by examination of undisturbed samples of soil, we can estimate within fairly close limits allowable bearing pressures, settlements, porosities, etc., of cohesive materials and we know the limits within which the early formulæ for lateral pressures are applicable. We do not know several important facts exactly, but we understand the limits and the tendencies much better.

Another branch of the same problem is that of soil stabilisation, mainly in connection with road works. The fame of Roman roads becomes more than justified when we realise that it was only towards the middle of the Nineteenth Century that we again began to approach their standards of road construction. In the early Nineteenth Century, McAdam developed what is now called waterbound macadam, and after another hundred years the use of bituminous materials for binding the macadam spread over the civilised world, mainly because of the growing pressure of motor transport. In undeveloped countries there is always a great necessity for cheaply constructed roads, and the so-called "dirt road" is a very important part of their economy. There have been continued efforts over the past 30 years to achieve stable surfaces at the lowest possible cost, ranging from soil-cement mixtures through soil-chemical mixtures to oil-bound or molasses-bound mixtures. The first is simply an artificial hard surface; the second, a method of controlling the moisture content; and the third, a waterproofing and binding process. Water content is the key to most soil-stabilisation problems and a technique of grading and compacting has been established. The natural progression is to waterproofed surfaces where the climate is wet, and many airstrips during the past war were covered with prefabricated bituminous surfacing, which was simply rolled off in strips like wallpaper.

Pervious water-bearing granular materials can now be changed into artificial rock by injecting certain chemicals. This is a very useful process when dealing with excavations, as it solves both the excess-water and the strength problems in a single operation. Sometimes it is only necessary to provide a relatively impervious curtain under, say, a river barrage, and injections of finely-divided bituminous materials have been successful in filling the pores of natural sands. Clays cannot be treated by any of these methods, as the pore space is too small; for the same reason, they drain but slowly. Clays have been hardened and drained by electrical methods, and works which would have been impossible in the natural material have been carried out. The consumption of electricity is too high for widespread commercial usage, the method has only a limited value in some types of clay.

Tunnelling is another very ancient and important form of earthwork. A roadway tunnel through the Alps was started, though not completed, as long ago as 1450, but we can say that modern tunnelling practice is largely the outcome of the accumulated experience of the past hundred years or so. A century ago, black powder was the only explosive used, but it has now been entirely superseded by gelignite or similar high explosive. Liquid air has been used, but generally in surface work only, as there are disadvantages involved in its volatility. At that time, also, handwork was used in drilling and clearing, haulage was by man or animal power, lighting by oil lamps, and ventilation fortuitous. It was in connection with the Mont Cenis tunnel that power drills were devised and first used in 1861, and the physical difficulties involved on other Alpine tunnels provided a great forcing ground for the refinement of tunnel technique.

When tunnelling in soft ground, we meet another range of problems. Generally, the walls, roof and sometimes the floor have to be supported by various methods such as timbering, lining with brick, concrete, cast iron, or steel. When water troubles are experienced, the work can be carried on in compressed air or by artificial consolidation of the material. In many cases, the use of a shield at the working face is either necessary or economical. The first shield was patented by M. I. Brunel in 1818 for use in the construction of the first Thames tunnel, which must rank as a major engineering achievement, considering the difficulties involved. The next shield was designed by Greathead for the Tower Subway, and this was the prototype for the modern shield, which can cater for a considerable range of earth conditions. With a modern shield and mechanical excavation, a 12-ft. tunnel in London clay can be advanced by as much as 160 ft. a week.

When we recall the Mole and Pharos at Alexandria and the layout of some other classical harbours, we realise that the historical maritime civilisations of the Mediterranean had available a great measure of technical ability. Indeed, there is some doubt whether the intervening period up to about the Eighteenth Century was one of progress at all. Men had continued to off-load ships on to shores or small wharves, and commerce was so small that there was little urge to do otherwise. By the early Eighteenth Century, however, commercial maritime transport was growing in importance, and wet docks were becoming a necessity. A slow steady progress was maintained, with wharves and port ancillaries growing larger as the size of ships increased. Up to the end of the last century, much of this work was carried out in the traditional Cyclopean masonry, but with the development of concrete this form of construction became modified in many circumstances, as the walls could be cast *in situ*. The use of reinforced concrete enabled heavier jetties and wharves to be constructed, but development was really only in the increased scale of works. In the present century, we have seen a number of interesting changes; for example, in the development of steel sheet piles which enable wharves to be built with considerable speed, in the development of iron screw piles into steel screw cylinders with greatly increased range of usefulness, and in the development of constructional technique like the Wellpoint system of ground-water lowering.

The recent war saw a great increase in what is called prefabrication. This can be defined as the practice of partly fabricating structures in the shops so that they may be assembled rapidly at the final location. The idea is not new, nor is it always economical, but the scale on which it was practised during the war is certainly new and may affect certain changes in peacetime construction. The invasion harbours were the crowning achievement of prefabrication. Less publicised were the permanent wharves for the heaviest loadings which were built in some of the Scottish sea-lochs. These were built by screwing down steel and concrete cylinders, 3 ft. in diameter, into the bed of the sea and then placing a prefabricated concrete deck on top. Speed of construction was considerable and the wharves handled a large part of the United States armed forces entering this country. Farther south, large forts complete with guns were built in dockyards and floated out to the required sites in estuaries, where they were sunk in position to form fixed strong-points.

With the ever-increasing complexity of the technical demands of society, we have had to handle problems which are either not susceptible to mathematical analyses or only laboriously and impractically so. In consequence, we have developed analysis by experimental methods to a considerable pitch. For direct stress measurement, the electrical-resistance strain gauge has been much used recently for a wide range of problems. When we have to consider internal stresses in structures, the practice of photo-elastic analysis is of great value. As long ago as 1816, Brewster noted that strains in crystals affected their optical properties, and since then the effect has been developed into a process in which scale models made from a clear medium like celluloid are stressed and analysed by polarised light. In the main, only two-dimensional problems are considered, but three-dimensional analyses can be carried out within limits. Though it cannot be said that photo-elastic methods are either simple or flexible, they have been the only practical approach to many problems. More recently, Professor Southwell's relaxation methods of mathematical analysis have proved useful in a great range of problems.

Another great field of experiment is that associated with fluid dynamics. Aerodynamics is now one of the major sub-sciences, and its success can be gauged by the fact that very few aircraft failures to-day can be traced to poor aerodynamic design. Much of the research effort is now directed towards the piercing of the sonic barrier, and, though we have reached velocities approaching that of sound with conventional aircraft, the next step will depend greatly on wind-tunnel models and probably as much so on free-flying models fitted with automatic recording and transmitting apparatus. In civil engineering, the importance of aerodynamics is not so great, but the recent failure of the Tacoma Narrows suspension bridge in a 30-m.p.h. wind has heavily stressed the necessity for aerodynamic investigation in cases where structural oscillation can occur. Hydrodynamics has probably greater capital importance even than aerodynamics. As long ago as 1872, Froude carried out his famous work on the resistance of motion through water. Since then, the use of scale models has produced great improvements in hull forms, from barges to the largest liners. More recently, it has been possible to represent the behaviour of vessels by self-propelled models.

One of the great commercial marine problems is that of alterations in existing regimes, for example, silting and erosion. For this purpose, a model concerned with improvements to the Garonne was constructed as long ago as 1875. The first really scientific models, however, were built by Professor Osborne Reynolds at Manchester University, and Professor A. H. Gibson's model there, 12 years ago, in connection with the Severn Barrage, is now classical. By a suitable choice of scales and materials, it was possible to reproduce 78 years of the history of the estuary closely, and by inference, the future could be foretold. Several models have since been constructed for estuaries, ports or rivers in all parts of the world, with considerable success.

In the construction of dams one of the more important aspects is the disposal of flood water over or around the structure. When we consider that even a medium catchment area in this country can produce several hundred tons of flood water per second, a considerable amount of energy has to be dissipated if the water flows over the crest of the dam, which may be upwards of 100 ft. high. Where sound rock occurs near the surface, the solution is simple, but where this is not so, considerable excavation for spillways may be necessary, and economy in design becomes very important. Models in laboratory conditions are very useful for this purpose.

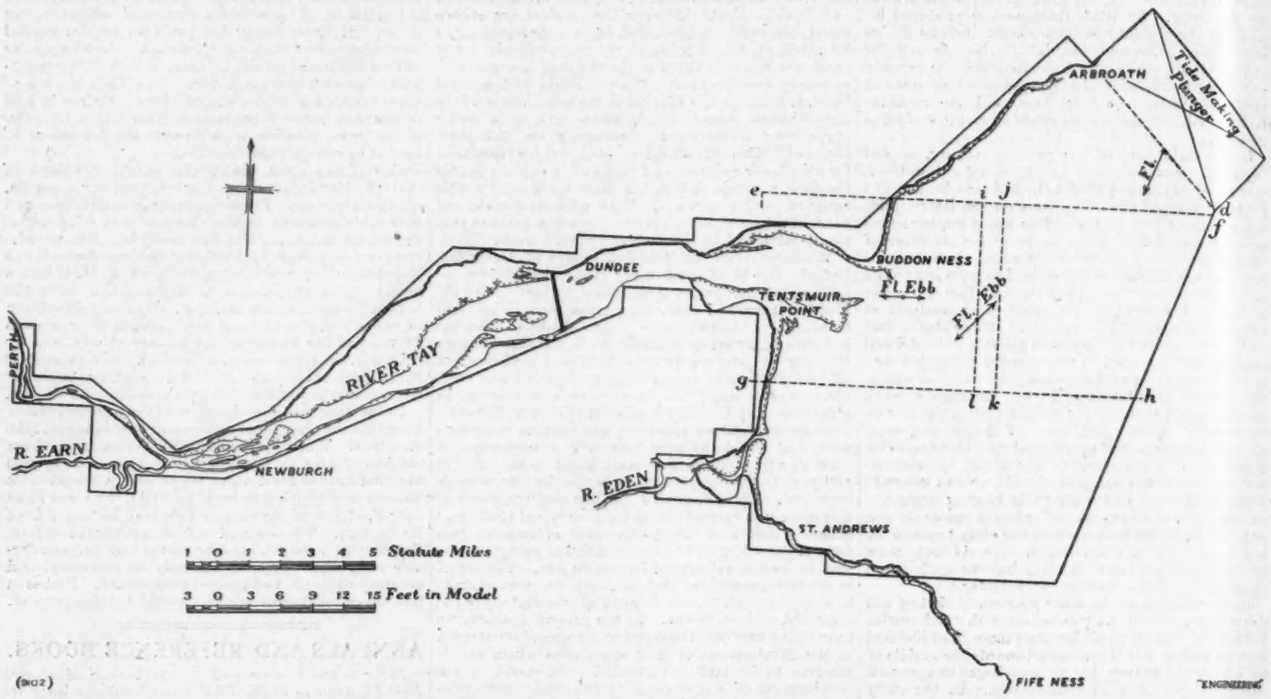
ANNUALS AND REFERENCE BOOKS.

Index to the Literature of Spectrochemical Analysis. Part II, 1940 to 1945.—The first of these indexes to the literature of spectrochemical analysis, published in 1940 by the American Society for Testing Materials, contained 1,467 references and covered the years 1920 to 1939, inclusive. The second, compiled by Bourdon F. Scribner and William F. Meggers, of the National Bureau of Standards, Washington, D.C., contains 1,018 references covering the years 1940 to 1945, inclusive, preceded by 36 additional references for 1938 and 1939, which were omitted from the earlier volume. For each year, the literature is arranged in alphabetical order of the authors' names, the items being numbered consecutively and referred to by these numbers in a detailed subject-index. Titles of books are given in the original language and titles of papers in English. Each entry gives the name of the publisher and references to the journal in which the paper is published and to any other in which an abstract of the paper appears. Spectrochemical methods were extensively exploited and considerably developed during the war years, and, despite the obstacles to scientific publication, a substantial proportion of these investigations were reported, in a wide variety of journals. As few institutions could secure complete sets of scientific periodicals covering this period, it was decided to supply, in this second *Index*, abstracts of the material listed. Such as had already appeared in *Chemical Abstracts* or elsewhere were critically reviewed and those approved are quoted verbatim. Where existing abstracts were deemed unsatisfactory, fresh ones were prepared. The inclusion of these abstracts has doubled the size of this volume, but has probably more than doubled its usefulness. The *Index* can be obtained from the American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A., at the price of 3.00 dols.

TRAFFIC AT ANTWERP.—During the month of June, 716 sea-going vessels, having an aggregate tonnage of 1,757,597 tons, entered the port of Antwerp, Belgium, compared with 451 ships and 894,302 tons in the corresponding period of 1946. The sea-going vessels which entered, flying the British flag, during June, 1947, numbered 174, totalling 314,075 tons.

THE LATE MR. A. JOLLIE.—We note with regret the death of Mr. Andrew Jollie, of Coldingham, Berwickshire, which occurred after an operation on Friday, August 22. Mr. Jollie was chairman of Messrs. Steel, Peech and Tozer and a director of the United Steel Companies, Limited, Sheffield. He retired from active participation in the affairs of the company in October, 1945, after completing nearly 50 years in the steel industry, the last 25 with Steel, Peech and Tozer. He had been a leading figure in the wheel, tyre and axle industries and was chairman of the National Association for Rolled and Re-Rolled Steel Products, in the formation of which he was one of the principals. He was also chairman of the Billet Association.

TIDAL MODEL OF THE FIRTH OF TAY.



TIDAL MODEL OF THE FIRTH OF TAY.*

By PROFESSOR J. ALLEN, D.Sc., M.I.C.E.

SOME sixty years ago, the British Association had the opportunity of inspecting tidal-model experiments by Osborne Reynolds in Manchester; Reynolds' fundamental work in this sphere was, in fact, carried out on behalf of a committee of the Association. This may lend added interest to the facilities granted this year by the Dundee Harbour Trust for a visit to their model of the Firth of Tay, and it is hoped that the construction of the model will be sufficiently advanced for members to see it in operation. It is unlikely, however, that there will have been time to make the adjustments which are usually necessary before such a model is ready for experiments of an exploratory nature.

A scheme for developing the harbour at Dundee was prepared a few years ago by the engineer to the Trust, Mr. N. A. Matheson, M.I.C.E. His proposals involve the construction of works extending about 1,100 ft. into the estuary, and he advised the Board that the effects of such works upon the general regime of the Firth of Tay ought first to be investigated by means of scale-model tests. There is also a problem associated with the behaviour of the channel through the outer bar. Four years ago, a sensibly straight cut was made through the bar, almost due east towards the North Sea; it is hoped that the model may show whether this is the best alignment and what measures, if any, would be desirable to ensure the stability of the channel. In addition, the thought has been kept in mind that the model might prove useful at some future time in studying phenomena or proposals, such as might be connected with large-scale reclamation, new bridges, etc. The model has been constructed, therefore, in a casing of reinforced concrete, largely precast, supported on brickwork and lined with mineral felt. The Dundee Harbour Trust decided to proceed with the model in February, 1945, but it was necessary to bring the knowledge of the estuary up to date and to obtain various hydrographic and other data. A large part of the estuary was re-surveyed, using echo-sounding apparatus to a considerable extent. In addition, information was obtained regarding the nature of the bed of the estuary, as revealed by sieve, microscope and specific-gravity tests on a number of samples; it was especially desired to detect the presence of any hard or heavy shoals or cohesive mud. The amount of suspended silt and the salinity of the water at various points and at different stages of the tide were ascertained, samples being filtered and specific-gravity measurements made for these purposes. The drift of the flood tide outside the mouth of the Firth was observed, as influencing the choice of the seaward limit of the model and the position of the tide-making mechanism. To obtain the rate of rise and fall of the tides, typical tide-curves were observed by direct readings on gauges at Buddon Ness, Dundee, Newburgh and Perth, both at springs and neaps. In each case, the four gauges were read simultaneously on one and the same tide. Not only was this information essential for the design of the tide-generator; it will also be invaluable in checking the behaviour of the model under running conditions.

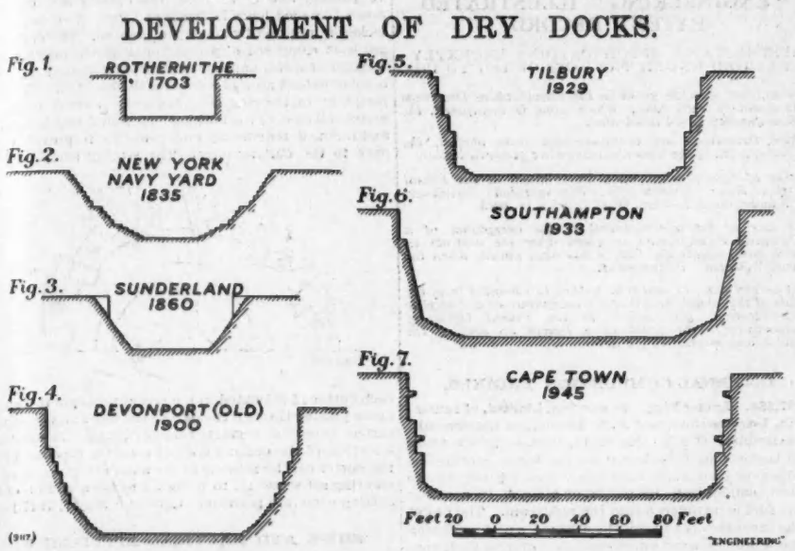
The scope of the model is shown in the accompanying diagram. In choosing the boundaries of a model of this kind, it is essential to consider the direction of the tidal currents. These vary from stage to stage of the tide. Arrows are shown in the diagram to indicate their general directions at the northerly extremity of the model and near the mouth of the estuary. The easternmost boundary has been set in the direction of the flood tide in the open sea, and the orientation of the tide-producing plunger has been fixed by compromise, allowing for the fact that close inshore, near Arbroath, the flood currents will tend to make generally parallel to the shore. Provision has been made for a group of baffles to guide the flood stream at the entrance to the model in the proper direction, if they should prove to be necessary. It is believed that the boundaries of the model have been placed sufficiently far from the works under investigation to warrant the assumption that conditions at the seaward limits of the model will be sensibly unaffected by the proposed works.

The scales of the model are as follow. The horizontal scale is 1 : 1,760, or 3 ft. to the mile; the vertical scale, 1 : 144, or 1 in. to 12 ft.; the scale of horizontal velocities, $1 : \sqrt{144}$, or 1 : 12, or 1·69 in. per second represents one knot; and the scale of time, 1 : 1,760/12, or 1 : 146·7, or 59·8 hours in the model represents one year of tides. The tidal period in the model (from one high water to the next) = 5 minutes 4 seconds, representing 12·4 hours; the ordinary spring tide range at Dundee = 1·25 in., representing 15 ft. (The mechanism can be easily adjusted to give spring tides either appreciably higher or appreciably lower than this.) The tides are generated by means of a counterbalanced steel plunger, 17 ft. long by 7 ft. 3 in. wide at the top and 5 ft. wide at the bottom, having a vertical movement, the stroke being automatically reduced through epicyclic gearing from spring tides to neaps and thereafter increased again to the following springs. For convenience, the mechanism can be arranged alternatively to create either spring tides only or neap tides only. The loaded weight of the plunger is approximately 7 tons and the counterbalance weight, suspended from a cam designed to allow for the varying buoyancy of the plunger at different stages of the tide, is about 2½ tons. The volume of water displaced on an ordinary spring tide is 185 cub. ft.; river water can be supplied, at various rates of flow, through calibrated orifices, to the Tay, the Earn and the Eden. A discharge of 1,000 cusecs in Nature is represented by $\frac{1{,}000}{1{,}760 \times 144 \times \sqrt{144}}$ or $3{\cdot}28 \times 10^{-4}$ cusec in the model. The first experiments will be devoted to checking the reproduction of hydraulic effects, such as tide and current phenomena. For this purpose, it is desirable that the configuration of the bed should not change too much as compared with the conditions at the time of the corresponding observations in the Firth of Tay itself; accordingly, the sandbanks have been moulded in sand obtained from the estuary. This sand has been dried and sieved through a coarse mesh to get rid of pebbles and shells. It has also been retained on a No. 60 mesh sieve, and the sand passing through this finer sieve has been kept for future use during tests on the schemes under investigation. Certain banks in the region of Broughty Castle, which are known to be comparatively stable, have been reinforced in the model with cement. The overall length of the model is 125 ft. and its greatest width is 52 ft. It has been constructed by Mr. N. A. Matheson, M.I.C.E., and the staff of the Dundee Harbour Trust.

* Paper read before Section G of the British Association at Dundee, on Friday, August 29, 1947. Abridged.

FLANDERS FAIR.—The Flanders International Fair will be held in Ghent from September 20 until October 4. Particulars may be obtained from the permanent secretary, 17, Rue des Flanders, Ghent, Belgium.

COURSE IN TOWN PLANNING.—Particulars regarding a three years' course of evening study in "Planning," to be held in the School of Architecture, Surveying and Building, the Polytechnic, 309, Regent-street, London, W.1, have now been issued. The course has been designed to meet the need of three types of students. In the first category are the qualified architect, engineer or surveyor who intends to take up planning as a profession, and, in the second, the specialist in certain subjects who may desire to obtain a fuller understanding of the contribution he can make to physical planning. In the third category is the administrator, who wishes to be better qualified to form a sound judgment on technical and design matters. The first two years of the course consist of an integrated programme of lectures and practical work, and members will be required to attend on three evenings a week for three terms, each of 12 weeks. The third year is arranged on tutorial lines. A programme of study will be set for each member individually and attendance at the School will only be required occasionally for supervision periods or special lectures. Further particulars may be obtained from the head of the School, at the above address.



THE DEVELOPMENT OF DRY DOCKS.*

By H. RIDEHALGH, A.M.I.C.E.

SIR CYRIL KIRKPATRICK'S Vernon Harcourt Lecture on the Development of Harbour and Dock Engineering, before the Institution of Civil Engineers in 1926, opened with an excellent historical note on the growth of naval and commercial shipping from earliest Egyptian records onwards, and the importance of our maritime supremacy throughout the ages was clearly demonstrated. A later demonstration of the necessity for this supremacy was forthcoming during recent war years.

Facilities for ship repair have grown collaterally with construction, and the dry dock has consequently developed into the most important port facility for such repair work. There is little doubt that, in the early days, vessels were put ashore on suitable beaches at high tides and careened for bottom scraping and repairs, the sequel to this being to exclude the rising tide by surrounding the beached vessel with walls of brushwood and puddled clay. Some of the earliest writings indicate that this method did not long survive and primitive forms of slipways with equally primitive hauling arrangements, as depicted by de Belidor in *Architecture Hydraulique*, were in universal use up to the Fourteenth Century, although even as late as 1434 it is recorded that the naval vessel Grâce Dieu was beached and surrounded by puddled walls for repairs near Southampton. The first recorded construction of a dry dock in this country was at Portsmouth in 1495-96, the dock being rectangular in plan with two piled cut-offs across the entrance several feet apart, the space between them being filled with clay and stones after the vessel had entered. Such was the magnitude of this seal that men are stated to have worked for 29 days on the tides removing piles, clay and rubbish at the entrance before the docked vessel could be taken to sea.

Around this period there is confusion in the use of the word "dock," which was applied loosely and included tidal and protected building slips, and wet as well as dry docks, making it most difficult to trace development. The condition "dry," incidentally, was maintained at this time by the use of Archimedian and other primitive hand-operated screw pumps, although in almost all cases the floor was given a good fall to about mean sea level at the entrance and little pumping was required.

The Gabriel Rialls was docked on wooden blocks at Woolwich in 1518, and dry docks existed at Chatham and Deptford in 1653. A new dry dock was ordered at Portsmouth in 1666 at a cost of 2,100*l.*, but the clearest record of an early dry dock in this country is at the Howland Great Dock on the Thames in 1703. There were established there two dry docks, the largest, 247 ft. long, 44 ft. wide, "with 16 ft. 6 in. draught of water at a good spring tide,"† capable of receiving two of the largest merchant ships of that time, and a smaller dry dock 140 ft. long of similar width and entrance depth. From the notes, it would appear that entrance was only possible near the top of the tide, and, when docked, the hull of the vessel stood well above the cope, from which level it was shored. Even at this date it would appear that dry docks were little more than modified slipways, the upper portion of which was walled in with vertically sheeted timber or masonry and sealed off with double-leaf timber lock gates, which were introduced into this country on the canals during the Sixteenth Century. No doubt, the longitudinal fall in the floors of some modern docks is, in part, a perpetuation of its slipway origin.

The vertical-sided dock soon gave way to the almost saucer-shaped cross-section, primarily to cut down pumping, but also to provide better working conditions for those engaged on caulking and painting the curved timber hulls. With the advent of deeper-draught merchant and naval vessels, and consequently deeper docks, it became no longer possible to shore from the cope, and the altar was introduced for this purpose. The saucer-type cross-section had several disadvantages, chief of which was the lack of level working areas on the dock bottom. It is perhaps interesting to note at this stage the approximate relationship between length, width and cill depth. Length to entrance-width ratio was of the order of 3 or 3·5 : 1, and length-cill depth ratio roughly 9 : 1.

The development of steam power and its application to marine engineering in the early Eighteenth Century saw the introduction of the paddle steamer, and the increase in width of midship section was a contributory cause towards the trend of the cross-section back to the rectangular. Improved pumping facilities partly nullified the importance of reducing pumped volume. Dock floors, hitherto, had been either mud, natural rock or timber, the latter taking the form of a baulk grillage secured to timber piles, and the earliest departure from these forms resulted in the appearance of the now well-known problem of stabilising the floor against hydrostatic pressure. Nevertheless, with the application of iron, and much later steel, to ship construction and the consequent increase in the weight of vessels docking, we find that brick and masonry floors anchored to king piles were introduced with success, and later, the more familiar inverted arch made its appearance.

The sequence of progress in ship construction from timber to iron, iron to steel, sail to steam, and paddle to screw, all had their influence on the design of dry-docking facilities, though, due to the very slow transition, it is a little difficult to trace the trend with accuracy. It is significant, however, that at the time of the displacement of the paddle, around the middle of the Nineteenth Century, the length-width ratio had risen to roughly 5·5 : 1 and the length-cill depth ratio to something in the region of 15 : 1, although there were instances of this going as high as 20 : 1.

The necessity for crane facilities for handling ship's cargo and equipment also had its influence on cross-section design. In the early stages, crane piers were built up from the altars standing out into the dock, and it was not long before the line of the cope was brought forward towards the face of the crane piers. In addition to cutting excavation and pumping costs, this served to reduce the length of shores for the newer vertical-sided vessels. The flat-stepped wall face, however, was still retained in principle and the Sunderland dock section is fairly typical of the period. The development of railways and dredging equipment further influenced dry-dock design. Rail tracks were naturally run as close as possible to vessels in dock to make fullest use of crane handling capacity, and dredging opened up rivers and ports to shipping of deeper draught than hitherto. So we find a further reduction in the width between copes and increases in cill depth to the extent that, in the larger docks at the end of the Nineteenth Century, the length-entrance width ratio reached roughly 9½ : 1 and the length-cill depth ratio to as much as 26 : 1. Cross-sections of some early and some modern dry docks, drawn to a uniform scale, are shown in Figs. 1 to 7, herewith.

In the review of evidence given before the Dominions Royal Commission in 1917, it was established that unit transport costs fell with increased vessel length and proportionate increase in draught, it being pointed out, however, that the condition of the harbours and waterways of the world at that time would not admit the larger vessels necessary to achieve a substantial reduction in transport charges.

It is not surprising, therefore, that, subsequent to this date, port access was improved and much larger dry docks than hitherto were built, notably at Tilbury, Liverpool and Southampton, and the most recently completed docks at Sydney and Cape Town can be said to have been designed to handle the largest vessels, naval and merchant, visualised by those in authority as likely to be constructed during the next twenty years or so. It might be pointed out here that their construction was well advanced before the effect of atomic energy on ship design could be assessed. These docks are therefore worthy of a few moments' consideration, and it is to be noted that the chief new feature common to both is that the walls have become almost vertical and the altars, instead of being formed in the walls themselves, are wide and cantilevered out from the face. The use of cantilever altars may eventually be justified in practice, but it would appear that they must be liable to damage from vessels docking, unless protected, and will offer obstruction to floating shores, catamarans and rafts during flooding up and pumping down. There are, however, attendant advantages, notably in design, where it is more easily possible to keep the resultant pressure back towards the heel of the wall than in the normal wall with a stepped face.

At Tilbury, we find a tendency to abolish the altars by building a large height of the walls with a plain vertical face, relying on hydraulic bilge blocks to replace the more normal shores, whereas at Southampton mechanical shores have been preferred. The variety of present-day ship sections, particularly naval, might demand special arrangements for blocking and shoring, but it is not inconceivable that, with the tendency to abolish the altar, we shall also eventually lose the mechanical shores in favour of the hydraulic bilge blocks and plain wall. The bilge blocks appear to take up considerable floor area and their use for vessels of varying beam seems a most delicate operation, but in practice they are extremely simple to place and most effective, the resultant unrestricted working space between the ship's side and the dock wall offering considerable advantages.

Two recently constructed German docks might also be noted here, primarily because of their large entrance width and relatively shallow depth over the cill. At Hamburg and Wilhelmshafen, the entrances are approximately 197 ft. wide and 26 ft. and 29 ft. deep, respectively. The length in each case is 1,148 ft. and the wall faces are vertical, with no shores. The reason for these unusual dimensions is that the docks were designed primarily as shipbuilding docks where, if necessary, several vessels could be built at the same time, and, after hull construction had reached a suitable stage, could be floated out light to their fitting-out berths. Keel and bilge supports were laid at the commencement of construction, the bilge supports being mechanically operated.

If we omit these German docks on account of their special design, we find, in the case of the newest docks, that the length-entrance ratio has fallen to 8 : 1 and the length-cill depth ratio has remained at 26 : 1; and though, after reviewing the increases which have taken place during this century, it would be unwise to presume that maximum dimensions have been reached, it would appear that the depths of navigable channels available in the main ports and canals throughout the world may limit substantial increases for some years, unless considerable new and continued maintenance dredging is proceeded with.

On the subject of design, one must agree that the theory of the use of the inverted arch in the floor to resist hydrostatic uplift is perfectly sound, but in practice there have been many partial failures. The word "partial" is used because the failure does not represent the collapse of the arch as such but of the lifting of the upper portion of it, due to the full water head being resisted by a completely impervious paving course laid on the main mass of the floor. The floor is designed so that its thickness will contain the necessary arch rise and so that it will distribute the very heavy keel-block loads over the substrata. In most instances, and particularly in the wider docks, the former is the ruling case and a more economical solution would appear to be to achieve, firstly, keel-load

* Paper read before Section G of the British Association at Dundee, on August 28, 1947.

† N. Gould, *Commercial Docks*, Rotherhithe.

distribution and then adequately to vent the floor to relieve water pressure. Blocking and inefficiency of floor and wall vents are often pleaded against their adoption, but in any dry dock of average size the small cost of regular maintenance would be insignificant. Venting, of course, must always be considered in conjunction with any available information, describing the type and quality of the substratum, for it is quite possible that the adoption of floor venting might easily involve the operators in uneconomical pumping commitments to maintain the dock in a dry condition. Further, the effect of drawing a considerable volume of water through the subsoil, and with it sand and other fines, may result in settlement problems more serious than the initial one of putting in a heavy floor.

As previously mentioned, timber double-leaf gates were very popular and no less effective during the early stages of dock development and many, in fact, are still functioning efficiently in various parts of the country: whether economically or not is another matter. Lock gates were made of cast-iron ribs and sheeted with oak planking for the Ellesmere and Chester canal in 1800, and the gates for the dry dock at Montrose were built similarly of cast-iron ribs with wrought-iron boiler plating at about the same time. In 1851, the largest gates which had then been built wholly of wrought iron (excluding heel posts, which were of cast iron) were for the dry dock at the New York Navy Yard, each leaf being 36 ft. wide and 30 ft. 8 in. high, for which dock it was also claimed the first all-metal floating caisson was built in the previous year. It is these two types of closures which have formed the basis of design for dry-dock gates up to the present day—the hinged double-leaf gate having gradually fallen out of prominence as the water head to be sustained and the entrance width have increased, and because of the expensive work on hollow quoins and other masonry. Floating caissons have not altered fundamentally in design since that date, though detailing and constructional materials have improved considerably. It is interesting to note, however, that on the earliest caisson rubber seals were used on keel and stems and proved eminently satisfactory, as they are doing at the present day on the recently built caisson at Cape Town. No cill meeting face has been provided in the German docks mentioned, the caisson being a rectangular steel "floater" sealing at the apron and vertical meeting faces by means of flexible steel plates.

There is little doubt that there can be considerable saving in cost during entrance construction without loss of efficiency if the provision of granite quoins dressed and polished to extremely fine limits, as has been the almost universal practice hitherto, can be abolished in favour of some combination of flexible seal on the caisson and simple and less exacting detailing of the masonry meeting face itself.

The subject of caissons cannot be left without reference to sliding caissons, so well known and proved. Among the advantages claimed over the floater are that no floating berth is required and entrances can be built with vertical instead of battered sides necessary for floating caisson removal. One other advantage for the slider became evident during the recent war, when it was shown that that type was more stable under bombing when in position than the centre-keel floater. On the question of constructional methods, the most recent introduction has been that of welding. There has been some hesitancy on the part of owners to adopt this method because of the lack of experience of the strength of welded joints after immersion in sea water over a period of years. Experimental reinforced-concrete floating caissons have been built recently, with some measure of success.

Dock engineering is one of the most interesting branches of the profession and, in the author's relatively brief career, it has become abundantly clear that opportunity exists for revising some of the long-standing ideas of what are essential provisions in dry-dock works. A call for the standardisation and co-ordination of the many features of design, construction and operation was made by Mr. M. G. McHaffie, chief engineer of Southampton Docks, during a recent discussion at the Institution of Civil Engineers, and there is little doubt that an organised exchange and analysis of experience between those designing, building and operating docks would produce an abundance of ideas.

REVOCATION OF THE CONTROL OF MAGNESIUM.—The Minister of Supply has issued an Order entitled The Control of Magnesium (No. 5) (Revocation) Order, 1947, revoking the Control of Magnesium (No. 4) Order, 1942. The effect of the revocation, which came into force on September 1, is to free the acquisition, disposal, and use of all forms of magnesium and magnesium alloys from licensing and also to remove price control. From September 1, 1947, onwards, the Ministry of Supply will cease to sell magnesium direct to consumers. Arrangements have been made for supplies of magnesium to be distributed by Messrs. F. A. Hughes and Company, Limited, who will sell pure metal to all United Kingdom consumers, without restriction, at ½d. a pound delivered

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

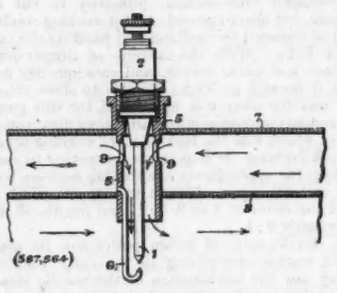
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

INTERNAL COMBUSTION ENGINES.

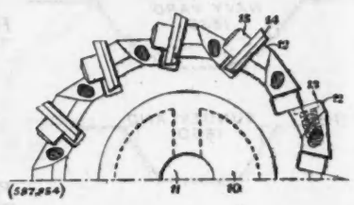
587,564. Igniter Plug. Power Jets, Limited, of Lutterworth, Leicestershire, and E. L. Meeson, of Lutterworth, Leicestershire. (1 *Fig.*) March 11, 1942.—The invention is an igniter plug for starting combustion in continuous-combustion gas-turbine machines where it is required to initiate combustion by means of a spark in a region where fuel is introduced into the airstream. The object of the invention is to keep the electrodes and insulation of the igniter in serviceable condition despite their continued exposure to heat and to the combustion products. The igniter plug is mounted in the wall of an air casing and extends across an air space through the wall of the combustion space into which the electrodes of the plug extend, the plug having a duct opening in the air space and leading air therefrom into the combustion space around the insulated electrode of the plug. The arrangement is such that there is a sufficient pressure difference tto ensure a current of air passing through the cavity,



which not only ventilates the cavity, but cools the electrodes of the plug. The complete igniter plug consists of a central electrode 1 leading out through insulation 2 to a terminal, the insulation being co-axially held by a gland nut in a body 5, from which there extends the "earth" electrode 6. The plug is fitted through a hole in the wall 7 of the air casing, within which is enclosed the wall 8 of the flame tube. The entry of the new air into the flame tube causes a certain pressure drop to occur, so that the pressure within the flame tube is lower than that in the air space. The sleeve 5 of the plug has openings 9 which admit air from the space between the walls 7 and 8 to the interior of the plug, this air escaping along the plug and out into the flame tube in the vicinity of the exposed ends of the electrodes. The ventilation thus provided reduces the formation of carbon and increases the length of life of the electrodes. (*Accepted* April 30, 1947.)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT

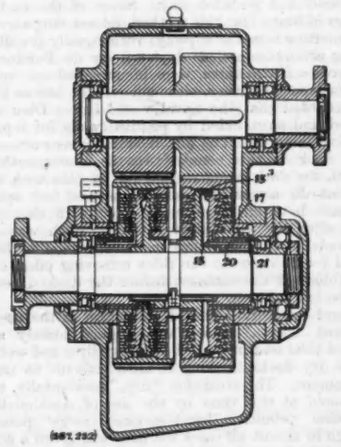
587,854. Rotary Metal-Cutting Tool. Samuel Osborn and Company, Limited, Sheffield, and W. Hulse, Sheffield. (6 *Figs.*) January 23, 1945.—The tool is constructed with a number of disc-like cutters attached at circumferential intervals to a rotary holder, to provide a ring of spaced circular cutting edges projecting from the periphery of the holder. Each cutter is secured by a set-screw, passing axially through it, to one of a ring of seating faces formed on lugs spaced at circumferential intervals on the holder. The cutters can be rotated, when the set screws are loosened, to bring fresh sections of their circular cutting edges into use in substitution for previously used and worn sections of their cutting edges. The tool consists of a holder 10 provided with a bore 11 for the spindle, and with a number of integral lugs 12 projecting from the front face of the holder. These lugs are spaced round the circumference of the holder and are provided with plane faces 13 forming seating surfaces for circular cutters 14. These cutters are detachable and adjustable and are secured, one to each lug, by set screws 15 passing axially through the cutters and engaging screw threaded holes in the lugs. The set screws 15 are locked in position by small grub screws. The cutters 14 are each composed of a compound unit consisting of a backing of metal and a cutting frontal ring of tungsten carbide welded around a boss on the backing. The front periphery of the ring constitutes the cutting edge, the peripheral faces of the backing and frontal ring being flush and inclined rearwardly and inwardly to provide clearance to the cutting edge. The seating surface 13 for



each cutter 14 is located in a plane at an angle to a radial plane passing through the axis of the tool and the seating surface to provide negative rake in cutting. In use, when a section of the cutting edge of a cutter becomes worn, the cutter can be rotated on its axis, after loosening its securing set screw 15, to bring an unworn section of the cutting edge into position. (*Accepted May* 7, 1947.)

SHIPS AND NAUTICAL APPLIANCES.

587,252. Marine Transmission. David Brown and Sons, (Huddersfield), Limited, of Huddersfield, Yorks., and N. Balmforth, of Huddersfield, Yorks. (4 *Figs.*) October 30, 1944.—The invention is an oil-operated friction clutch for use between the engine and propeller shaft of a marine engine. A casing contains two parallel shafts supported in bearings, one being the driven input shaft and the other the output shaft connected to the propeller. The input shaft has fast upon it two toothed gears and the output shaft carries two friction clutches, the axially-movable inner members 15 of which are splined to the shaft, while the axially-fixed outer members 17 run loose on the hubs of the inner members. The outer members of the clutches are toothed externally, one being geared directly to one gear on the input shaft and the other being geared, through an idler gear, to the other gear on the input shaft. The inner members 15 of the clutches have annular ribs of wedge form which, when the inner members are forced apart, engage in corresponding wedge-shaped annular grooves in the



outer members 17. By removing or supplying oil to the spaces between the movable inner members of the two clutches, either of the clutches can be engaged to provide an ahead or an astern drive, or both clutches may be disengaged to provide a neutral position. Each outer clutch member 17 has a toothed rim and two annularly-ribbed side plates which screw into internally-threaded portions of the rims, so that the plates are self-tightening as the rims are rotated. A peripheral flange 15^2 on one movable clutch member overlaps the periphery of the co-operating movable member, so that there is a sealed chamber between each pair of movable members. Oil under pressure can be admitted to grooves 21, cut in the bearing housings, from which it can pass along passages 20 to the sealed chambers. By means of a rotary valve, the sealed chamber of one clutch is exhausted as the chamber of the other is filled. The use of bearing housings to convey oil to passages in the clutches obviates the necessity for providing passages through the shaft on which the clutches are carried. (*Sealed.*)